POPULATION DENSITIES OF THE ALFALFA WEEVIL, HYPERA POSTICA (GYLLENHAL), IN ALFALFA, MEDICAGO SATIVA L., AS INFLUENCED BY FALL HARVEST, WINTER GRAZING, AND WEED CONTROL

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AND WEED CONTROL

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CHAPTER I

INTRODUCTION

Alfalfa, *Medicago sativa* L., is produced on ca. 200,000 ha in Oklahoma and generates over $100 million annually from the sales of hay and seed (Sholar et al. 1982). Because alfalfa buyers are willing to pay more for high quality forage, the incentive is becoming greater to produce the best possible forage for in the market place (Cuperus et al. 1984, Ward et al. 1984). The first crop which is harvested in early May, typically has the greatest yield and high quality. However, infestations of alfalfa weevil, *Hypera postica* (Gyllenhal), larvae occur throughout the growth of this crop and frequently economic threshold levels of 1.5-2.0 larvae per stem are exceeded (Berberet & Pinkston 1978). Since the first detection of the alfalfa weevil in Oklahoma (Curry 1968) it has become the most important insect pest of alfalfa throughout the state.

Adult weevils re-enter alfalfa fields following summer estivation during October and November in Oklahoma in search of overwintering habitat and ovipositional locations in fall growth. Higher weevil larval populations occur in fields with abundant fall growth than those with little plant material (Dowdy et al. 1986). This growth can be grazed during winter with resulting lower alfalfa weevil egg and larval populations (Senst & Berberet 1980). Winter grazing has been incorporated as an important aspect of integrated control for the weevil.

Another factor that influences alfalfa hay yield and quality is competition by annual winter weeds. These species germinate during late fall and winter when alfalfa is not actively growing. They compete for soil moisture, nutrients, and light with resulting reductions in growth and stem densities of alfalfa. In addition, the forage produced is lower in crude protein due to the low protein weed component (Temme et al. 1979).

Little has been done to document the interaction between the alfalfa weevil and annual winter weeds in alfalfa fields or to determine the combined effects on forage production and quality. The objectives of my research are:

1. To document the effects of late fall harvest and winter grazing in combination with alfalfa weevil and weed management on alfalfa forage yield, quality, and stand longevity.

2. To determine the influence of late fall harvesting and winter grazing in combination with weed control using herbicides on egg deposition and seasonal occurrence of peak larval populations of the alfalfa weevil.

3. To document the effects of alfalfa stem density and weed content in forage on the dynamics of alfalfa weevil populations.

4. To determine the effects of alfalfa weevil infestations and late fall harvest and winter grazing on total nonstructural carbohydrates in roots of alfalfa.

5. To consider if the cost of alfalfa weevil and weed controls with pesticides was justified by savings in alfalfa production in three alfalfa cultivars harvested in fall or grazed in winter.

CHAPTER II

LITERATURE REVIEW

Alfalfa Weevil Management

In Oklahoma, the alfalfa weevil, *Hypera postica* (Gyllenhal), re-enters alfalfa fields during October and November from summer estivation sites in fence rows and wooded areas and soon begins egg deposition (Berberet et al. 1980). The initial dispersal of adults is slow as weevils apparently crawl into field edges and feed for several days before flying to other locations and becoming distributed across fields (Blickenstaff 1967, Pausch et al. 1980).

Oviposition typically continues throughout the winter in Oklahoma, except for intermittent periods when temperatures drop below the ovipositional threshold of 1.6°C (Berberet et al. 1980). When sampled in January, eggs have a higher viability than those collected in late February or March due to the accumulation of inviable eggs through the ovipositional period (Townsend and Yendol 1968). Egg viability is greatest in portions of stems within 15 cm of the soil surface according to Dively (1970), who found that the highest percentage viability in spring was recorded in alfalfa stubble (75%). Percentages of viable eggs were lower in new growth (39%) and alfalfa that had reached bud stage in fall (13%). Shorter growth provided ovipositional locations near the soil surface only, which reduced exposure of the eggs to lethal low temperatures. Armbrust et al. (1969) reported that the lethal low temperature for weevil eggs was -21.9 and -23.8°C for eggs which are 5 and 10 days old, respectively.

Though lower viability was evident for eggs in taller stems, this environment is preferred by the weevil for oviposition because of the greater stem diameters which hold larger egg masses (VanDenburgh et al. 1966, Norwood et al. 1967a). Plants with small stems, little growth and wide crowns usually have few eggs (Norwood et al. 1967b). Removal of plant material containing eggs has been successful for reducing populations. Winter grazing of frost killed alfalfa stems by cattle reduced egg populations over 60% and also resulted in significantly lower larval populations (Senst & Berberet 1980). Spring pasturing by sheep in Idaho has also been effective to delay plant growth until most weevil eggs have hatched (Wakeland 1921). However, spring grazing may also reduce stand vigor by depleting root carbohydrate reserves as growth is initiated in spring.

Limiting ovipositional sites for the weevil in fall also results in less larval feeding damage in spring. Burbutis et al. (1967) documented in Delaware that the greatest feeding damage before first harvest occurred in plantings which contained a large number of fall laid eggs as compared to plantings with mostly spring laid eggs. If larval populations develop primarily from spring-laid eggs then alfalfa plants may grow with little weevil feeding damage in early vegetative stages. Larger plants are able to withstand greater larval populations (Hintz et al. 1976).

Larval densities of 1.5-2.0 per stem in alfalfa less than 25 cm tall can cause losses justifying chemical control costs of $20-25/ha (Berberet & Pinkston 1978). Yield reductions of 188 kg/ha accrue in the first crop with the addition of each larva per stem when alfalfa is infested at less than 25 cm (Berberet et al. 1981) and later crops may also yield less due to reduced plant growth and stem densities (Wilson et al. 1979). Protein content is greatly reduced in alfalfa leaves while that of stems is relatively unaffected by larval feeding (Liu & Fick 1975). Composite protein content of plants may not significantly decrease due to larval feeding (Berberet & McNew 1986) because plant growth is stunted and shorter stems that remain are typically high in protein and compensate for loss of the high protein leaf component. However, total production of protein per ha is reduced due to lower forage production (Kapusta et al. 1983).

By utilizing fall management practices such as grazing or late fall harvesting, it is possible to reduce oviposition during fall and winter and achieve the benefits of less larval feeding damage in spring. Planting improved alfalfa cultivars such as 'Arc' (Devine et al. 1975) that can withstand moderate larval feeding may further reduce the cost of producing high quality forage.

Weed Management

Another problem in maintaining vigorous alfalfa stands is competition for soil nutrients, moisture, and light by weeds. Annual weeds have lower forage quality than alfalfa which necessitates their control to maintain high quality production (Temme et al. 1979). Downy brome, *Bromus tectorum* L., contains less calcium, nitrogen, and potassium than alfalfa and only a third of the protein (Morrison 1956). By controlling competing plant species during establishment, seedling alfalfa plants are better able to develop adequate, healthy root systems and form large crowns (Schreiber 1960). In a complimentary manner, establishment of a vigorous stand is an important factor in preventing weed encroachment throughout the life of a planting by limiting opportunities for weeds to invade. Annual weed species which infest alfalfa in Oklahoma during winter are henbit, *Lamium amplexicaule* L., mustards, *Brassica* spp., and cheat, *Bromus secalinus* L. These species germinate when alfalfa is dormant and available light at the soil surface and moisture are greatest (Stritzke 1985).

Not only do some weeds reduce the feed value of the forage, but they also limit animal intake (Dutt et al. 1982). Mature downy brome is less palatable than alfalfa and possesses awns that may injure livestock when fed as dry roughage (Platt & Jackman 1946). Cultural practices for controlling downy brome have met with limited success as cultivation to remove this pest also injures alfalfa plants (Bruns & Heinmann 1959).

While cultivation (renovation) appears to be a questionable method for reducing weed populations in established alfalfa, timely cutting or grazing of fields has been effective in controlling field bindweed, Convolvulus arvensis L.; Canada thistle, Cirsium avese L.; and perennial sowthistle, Sonchus arvensis L. (Stahler & Derscheid 1948). These methods do not allow the weeds to reproduce and thus minimize their spread. Winter grazing may also be effective in minimizing infestations of annual winter grasses by reducing growth until alfalfa begins growth and becomes more competitive in late winter.

Chemical control of weeds is frequently used in alfalfa production. Winter annual weeds may make substantial growth when alfalfa is dormant in winter. During this time, herbicides can be used with the least likelihood of toxicity to alfalfa plants (Aldrich 1957). The most successful control of these weeds in Oklahoma is obtained from December to February when alfalfa is nearly dormant (Stritzke 1985). When properly applied, herbicides can reduce weed competition and maintain good alfalfa forage yield and quality (Peters 1964, Wilson 1981). Some weed infestations can be tolerated if weed populations are not causing losses exceeding control costs because adequate nutrients and water are present to support both alfalfa and weed growth (Kapusta 1983).

Insect-Weed Interaction

As a perennial, alfalfa offers a more stable environment than most other agricultural crops. Over a period of years, greater insect and plant diversity may develop than is typical of annual crops. The greater insect species diversity has been found to be dependent upon the presence of grasses and broadleaf weeds in established stands (Barney et al. 1984). Populations of the potato leafhopper, *Empoasca fabae* (Harris), are often significantly greater in plots containing broadleaf weeds than in plantings with grassy weeds (Lamp et al. 1984). Either a greater predator abundance occurs in grassy plots than in broadleaf weed infested plots or grassy weeds present a less desirable habitat for leafhoppers.

Some winter annual weeds serve as ovipositional sites for the alfalfa weevil (Ben Saad & Bishop 1969). Those present in Oklahoma include henbit and shepherdspurse, *Capsella bursa-pastoris* (L.) Medic. When henbit accounted for 50% or more ground cover, larval feeding damage was up to 75% greater than in fields with few or no weeds (Waldrep 1969), presumably due to greater egg densities in weeds.

Norris et al. (1984) recorded an increase in populations of the Egyptian alfalfa weevil, *Hypera brunneipennis* (Boheman), by 20 to 50% when winter annual weeds were controlled. Even though higher larval populations develop in the absence of weeds, reductions in forage yield were greatest from combined weed and alfalfa weevil infestations. In Illinois, Kapusta et al. (1983) also documented greater yield losses when neither insects nor weeds were managed with pesticides than when at least one pest type was controlled. The herbicides applied in the Illinois study probably caused injury to alfalfa plants resulting in reduced yields. When herbicides are applied to dormant alfalfa, injury can be minimized to alfalfa plants and successful weed management accomplished.

Because of interactions between the alfalfa weevil and annual winter weeds, an alfalfa management program should consider interrelationships of these pest problems. Regulation of weed and weevil populations can increase the quality and yield components of alfalfa. Greatest alfalfa production also occurs in plots which both weevils and weeds are controlled. The value of these controls will be dependent upon the density of both weeds and weevils.

LITERATURE CITED (CHAPTERS I & II)

Aldrich, R. 1957. Chickweed control in alfalfa. USDA Tech. Bul. 1174. 14p.

Armbrust, E. J., C. E. White, & J. R. DeWitt. 1969a. Lethal limits of low temperature for the alfalfa weevil in Illinois. J. Econ. Entomol. 62: 464-467.

Barney, R. J., W. O. Lamp, E. J. Armbrust, & G. Kapusta. 1984. INsect predator community and its response to weed management in spring-planted alfalfa. Prot. Ecol. 6: 23-33.

Ben Saad, A. A., & G. W. Bishop 1969. Egg-laying by the alfalfa weevil in weeds. J. Econ. Entomol. 62: 1226-1227.

Berberet, R. C., & K. N. Pinkston. 1978. Control of the alfalfa weevil in Oklahoma. Oklahoma State Univ. Ext. Facts No. 7166.

Berberet, R. C., K. M. Senst, K. E. Nuss, & W. P. Gibson. 1980. Alfalfa weevil in Oklahoma: the first ten years. Oklahoma Agr. Exp. Sta. Bul. B-751.

Berberet,R. C., R. D. Morrison, & K. M. Senst. 1981. Impact of the alfalfa weevil, Hypera postica (Gyllenhal), on forage production in nonirrigated alfalfa in the southern plains. J. Kansas Entomol. Soc. 60: 1185.

Berberet, R. C. & R. W. McNew. 1986. Reductions in yield and quality of leaf and stem components of alfalfa forage due to damage by larvae of Hypera postica (Coleoptera: Curculionidae). J. Econ. Entomol. 79: 212-218.

Berberet, R. C., J. F. Stritzke, & A. K. Dowdy. 1987. Interactions of alfalfa weevil (Coleoptera: Curculionidae) and weeds in reducing yield and stand of alfalfa. J. Econ. Entomol. 80: 1306-1313.

Blickenstaff, C. C. 1967. Winter distribution of adult alfalfa weevils within alfalfa fields. J. Econ. Entomol. 60: 1185.

Bruns, V. F., & W. W. Heinmann. 1959. Downy brome in alfalfa and related studies. USDA Tech. Bul. 1197. 28p.

Burbutis, P. P., D. F. Bray, & A. H. Mason. 1967. Overwintering eggs of the alfalfa weevil in Delaware. J. Econ. Entomol. 60: 1007-1010.

Cuperus, G. W., L. Rommann, & C. Ward. 1984. Haymarket: a computerized alfalfa marketing system. Oklahoma Coop. Ext. Ser. Current Rep. CR-465.

Curry, P. D. 1968. First report of the alfalfa weevil in Oklahoma. USDA Coop. Econ. Insect Rep. 18: 545.

Devine, T. E., R. H. Ratcliffe, C. M. Rinker, D. K. Barnes, S. A. Ostazeski, T. H. Busbice, C. H. Hanson, J. A. Schillinger, G. R. Buss, & R. W. Cleveland. 1975. Registration of Arc alfalfa. (Reg. No. 76). Crop Sci. 15: 97.

Dively, G. P., Jr. 1970. Overwintering alfalfa weevil eggs in three stages of alfalfa growth in New Jersey. Ann. Entomol. Soc. Amer. 63: 1213-1216.

Dowdy, A. K., R. C. Berberet, & J. L. Caddel. 1986. Population densities of alfalfa weevil, Hypera postica ((Coleoptera: Curculionidae), with varied fall planting dates for alfalfa. J. Econ. Entomol. 79: 790-796.

Dutt, T. E., R. G. Harvey, & R. S. Fawcett. 1982. Feed quality of hay containing perennial broadleaf weeds. Agron. J. 74: 673-676.

Hintz, T. R., M. C. Wilson, & E. J. Armbrust. 1976. Impact of alfalfa weevil larval feeding on the quality and yield of first cutting alfalfa. J. Econ. Entomol. 69: 749-754.

Kapusta, G. 1983. Influence of the control of seedling and winter and summer annual weeds on the yield and stand longevity of alfalfa. 1983 Prog. Rep. Belleville Res. Cen. So. Illinois Univ. 12p.

Kapusta, G., E. Armbrust, & W. Lamp. 1983. Influence of differential weed and insect control on insect populatins in alfalfa. I. Alfalfa and weed yields and alfalfa protein. 1983 Prog. Rep. Belleville Res. Cen. So. Illinois Univ. 7p.

Lamp, W. O., R. J. Barney, E. J. Armbrust, & G. Kapusta. 1984. Selective weed control in spring-planted alfalfa: effect on leafhoppers and planthoppers with emphasis on potato leafhoppers. Environ. Entomol. 13: 207-213.

Lamp, W. O., K. V. Yeargan, R. F. Norris, C. G. Summers & D. G. Gilchrist. 1985. Multiple pest interactions in alfalfa. In Integrated Pest Management on Major Agricultural Systems. R. E. Frisbie & P. L. Adkisson, eds. Texas Agr. Exp. Stn. MP-1616.

Liu, B. W. Y., & G. W. Fick. 1975. Yield and quality losses due to alfalfa weevil. Agron. J. 67: 828-832.

Morrison, F. B. Feeds and Feeding. Ed. 22, 1165p. illus. Ithica, New York. 1956.

Norris, R. F., W. R. Cothran, & V. E. Burton. 1984. Interactions between winter annual weeds and Egyptian alfalfa weevil in Alfalfa. J. Econ. Entomol. 77: 43-52.

Norwood, B. L., D. K. Barnes, R. S. VanDenburgh, C. H. Hanson, & C. C. Blickenstaff. 1967a. Influence of stem diameter on oviposition preference of the alfalfa weevil and its importance in breeding for resistance. Crop Sci. 7: 428-430.

Norwood, B. L., R. S. VanDenburgh, C. H. Hanson, & C. C. Blickenstaff. 1967b. Factors affecting resistance of field-planted alfalfa clones to the alfalfa weevil. Crop Sci. 7: 96-99.

Pausch, R. D., S. J. Roberts, R. J. Barney, & E. J. Armbrust. 1980. Localized field migration of the adult alfalfa weevil, clover leaf weevil, and clover root curculio, and its implication for a fall pest management program. The Great Lakes Entomologist 13: 195-200.

Peters, E. J. 1964. Pre-emergence, preplanting, and post-emergence herbicides for alfalfa and birdsfoot trefoil. Agron. J. 56: 415-419.

Platt, K., & E. R. Jackman. 1946. The cheatgrass problem in Oregon. Oregon St. Col. Ext. Bul. 668. 47p.

Schreiber, M. M. 1960. Pre-emergence herbicides on alfalfa and birdsfoot trefoil. Weeds 8: 291-299.

Senst, K. M., & R. C. Berberet. 1980. Effects of winter grazing of dormant alfalfa stands on populatins of Hypera postica (Gyllenhal) and its parasite Bathyplectes curculionis (Thomson). J. Kansas Entomol. sOC. 53: 230-234.

Stahler, L. M., & L. A. Derscheid. 1948. Cultural methods of noxious weed control in South Dakota. South Dakota Agr. Exp. Sta. Circ. 75. 8p.

Stritzke, J. F. 1985. Weed control in alfalfa. Oklahoma St. Univ. Ext. Circ. E-840.

Temme, D. G., R. G. Harvey, R. S. Fawcett, & A. W. Young. 1979. Effects of annual weed control on alfalfa forage quality. Agron. J. 71: 51-54.

Townsend, H. G., & W. G. Yendol. 1968. Survival of overwintering alfalfa weevil eggs in Pennsylvania. J. Econ. Entomol. 61: 916-918.

VanDenburgh, R. S., B. L. Norwood, C. C. Blickenstaff, & C. H. Hanson. 1966. Factors affecting resistance of alfalfa clones to adult feeding and oviposition of the alfalfa weevil in the laboratory. J. Econ. Entomol. 59: 1193-1198.

Waldrep, T. W., D. S. Chamblee, D. Daniel, W. A. Cope, & T. H. Busbice. 1969. Damage to alfalfa by the alfalfa weevil as related to infestatin by henbit. Crop Sci. 9: 388.

Ward, C. E., G. W. Cuperus, & L. M. Rommann. 1984. Haymarket: a first year summary. Oklahoma Coop. Ext. Ser. Current Rep. CR-477.

Wilson, M. C., J. K. Stewart, & H. D. Vail. 1979. Full season impact of the alfalfa weevil, meadow spittle bug, and potatoe leafhopper in an alfalfa field. J. Econ. Entomol. 72: 830-834.

Wilson, R. G., Jr. 1981. Weed control in established dryland alfalfa. Weed Sci. 29: 615-618.

Wolfson, J. L. & K. V. Yeargan. 1983. The effects of metribuzin on larval populations of alfalfa weevil, _Hypera postica_ (Coleoptera: Curculionidae). J. Kansas Entomol. Soc. 56: 40-46.

Chapter III

LATE FALL HARVEST AND WINTER GRAZING EFFECTS ON ALFALFA

Harvesting alfalfa, *Medicago sativa* L., in late fall or grazing in winter have been shown to be excellent methods of utilizing fall growth without apparent reductions of future productivity or stand retention (Hanley et al. 1964, Sholar et al. 1983). An additional benefit of removing the fall growth is reduction of overwintering habitat and ovipositional sites for adult alfalfa weevils, *Hypera postica* (Gyllenhal), which tend to favor areas with abundant plant growth (Dively 1970, Dowdy et al. 1986). Along with reduced oviposition comes the potential for delaying the occurrence of peak larval populations. Reducing numbers or delaying the occurrence of peak larval populations may result in maintaining good alfalfa yields and limiting control costs (Berberet et al. 1981).

Not only are insect populations influenced by harvest management, but encroachment by certain weed species may also be affected. In England, spring grazing of alfalfa with sheep resulted in encroachment of annual broadleaf and perennial grass weeds but a reduction in annual grasses (Gibson et al. 1987b). In Oklahoma, winter weeds such as cheat, *Bromus secalinus* L., have a period of minimal competition from alfalfa due to their active growth while alfalfa is dormant. By opening the crop canopy through the removal of fall growth more light contacts leaves of seedling weeds and may enhance establishment and competitiveness when alfalfa dormancy is broken in late winter.

Stress on alfalfa plants from insect feeding damage and/or weed encroachment results in reduced forage yield and stand retention and may further be compounded with the addition of late fall harvesting or early winter grazing. Perennial grass populations increased more rapidly in alfalfa grazed by sheep when insect controls were not utilized than when they were utilized (Gibson et al. 1987a). In alfalfa left unharvested through winter, Berberet et al. (1987) documented the greatest alfalfa yield reductions where neither weevils nor weeds were controlled. Relative to pest-free stands the decrease in production from combined alfalfa weevil-weed infestation was greater than the sum of losses caused by each pest type individually. Norris et al. (1984) recorded 1.2-1.5 times more larvae of the Egyptian alfalfa weevil, *H. brunneipennis* Bohman, where weeds were controlled but greater loss in alfalfa yield again resulted from combined weed and insect pest stress.

The presence of weeds reduces the overall forage protein and digestibility (Cords 1973, Temme et al. 1979). Alfalfa weevil larval feeding reduces crude protein by removing the leaf component of alfalfa (Berberet & McNew 1986). The objectives of this chapter were to document the effects of late fall harvest and winter grazing in combination with alfalfa weevil and weed management on alfalfa forage yield, quality, and stand longevity.

Materials & Methods

This study was conducted at the South Central Research Station at Chickasha, Oklahoma on an irrigated alfalfa stand established in the fall of 1981. The experimental design was a split plot in strips configuration with four replications of the alfalfa cultivars 'Arc' (Devine et al. 1975), 'OK08' (Oklahoma common), and 'WL318' (Beard & Kawaguchi 1978) on main plots. Subplots positioned in strips across the main plots were harvest management options consisting of late fall harvest (November) or winter grazing (December and early January) at a stocking rate of 12-15 cattle/ha for a 2-3 wk period. The third subplot was left uncut and ungrazed to determine the potential for egg and larval populations where fall growth remained. The final harvest of the season on these plots was taken in mid-September after which plants produced ca. 20-25 cm of fall growth.

Carbofuran insecticide and the herbicides, terbacil and oryzalin were applied annually in a 2 x 2 factorial design on sub-subplots within each cultivar by harvest management combination. The resulting treatment combinations included 1) insecticide only to control weevils and allow weed infestation, 2) the herbicides only to control weeds and allow alfalfa weevil infestation, 3) both insecticide and herbicides to create a "pest-free" treatment, and 4) unsprayed plots to allow infestation of both weevils and weeds. Naturally occurring insect and weed populations were utilized until the summer of 1985 when cheat was seeded (@ 15 kg/ha) to increase the potential for weed competition during winter and spring of 1986 and 1987. Harvest and pesticide treatments were first imposed in the fall of 1982 and spring of 1983, respectively.

Alfalfa weevil larval populations were sampled (25 stems/sub-subplot) at 3 or 4 weekly intervals to determine peak densities. The sampling period was adjusted based on the evidence of feeding damage and accumulation of degree days for weevil development. Larvae were separated from plant material for counting with Berlese funnels.

Weed content (%) in forage was determined throughout the study with visual estimates at each harvest in each sub-subplot. These estimates were used to calculate the weight of weeds and alfalfa produced/ha. Weed and alfalfa components were separated and weighed from 0.5 m^2 quadrats to assure accuracy of visual estimates several times throughout the study.

Four or five harvests were made with a flail type harvester each summer at 10-30% bloom stage with yields estimated from a 1 x 5 m area in each sub-subplot. Subsamples (300-400 g) of forage were taken for dry matter determination and crude protein analysis. The amounts of forage contributed by the late fall harvesting and winter grazing were calculated from 0.5 m^2 quadrat samples collected at the time of the late harvest. Crude protein content was determined by the macro-Kjeldahl method at the Oklahoma State University Forage Quality Laboratory.

Stem densities were determined by counting alfalfa stems in five, 0.1 m^2 quadrats in each sub-subplot prior to harvesting to document the effects of the various management regimes on stand retention. At the termination of the study in September 1987, alfalfa plants were undercut from a 1 x 5 m strip in each sub-subplot and the number of plants were recorded.

All data were subjected to the analysis of variance procedure and F-tests were utilized to detect significant interactions between treatment components (SAS 1985). Mean separations were accomplished with least significant difference tests at the 0.05 level of probability (Steel & Torrie 1980). All data are presented by subplot or sub-subplot to facilitate communication of the effects of treatment levels over years. Therefore, calculated F values obtained through analyses of the data in a split-plot in strips configuration are not necessarily descriptive of the means presented for main plots and subplots. All F values and associated degrees of freedom are presented in Appendix B.

Results

1983 (Season 1)

Rather than a presentation of detailed analysis of each harvest throughout the study, I have selected harvests of each year that show how treatment combinations affected forage production. Additional harvest data are located in Appendix A. Seasonal forage totals are presented at the end of each section and overall forage totals for the entire study are presented after all seasonal results.

In 1983, peak alfalfa weevil larval populations occurred in early May and were significantly reduced by insecticide with means of less than 0.1 larvae per stem compared to 3.1 per stem in sub-subplots not sprayed with insecticide. Larval feeding damage ratings (scale of 1= no damage and 9= complete defoliation) averaged 1.7 and 4.0 in sub-subplots treated and not treated with insecticide, respectively. First harvest was made soon after peak larval density was reached (12 May). The percentage of weeds in the forage at first harvest averaged 0.0-8.8% with most weedy material in unsprayed sub-subplots. Cultivars were similar in total forage and alfalfa yields. Harvesting in late fall or grazing in winter did not reduce first harvest total forage or alfalfa yields relative to alfalfa left unharvested through the winter. Applications of insecticide generally resulted in a significantly greater alfalfa yield at first harvest than when weevils were not controlled below the economic threshold of 1.5-2.0 larvae per stem. Treatment with herbicides tended to result in lower total forage yield than the sub-subplots not treated with herbicides. This was not only due to removal of the weed component but also some injury to alfalfa plants may have occurred as alfalfa yields tended to be lower (Table I).

Crude protein content of forage at first harvest averaged 17.5% and was similar among cultivars and harvest management treatments (Table I). Neither alfalfa weevil nor weed infestations consistently reduced protein content. Since peak weevil larval populations did not occur until just prior to the first cutting, there was limited time for defoliation and subsequent reduction in forage quality. Additionally, weed infestations were low in all treatment combinations and detracted little from overall forage quality.

A total of four harvests were made through the summer of 1983 and treatment combinations exhibited minimal influence on total forage or alfalfa yields. The fall harvest treatment was imposed 16 November in 1983 and yielded 1.1 Mg/ha of alfalfa with only slight weed content. Forage available for grazing in winter also averaged 1.1 Mg/ha when sampled at the same time. These values were included in the seasonal totals in Table II. The subplots that were left unharvested through winter were last cut 16 September and fall growth remained.

Seasonal total forage production from four harvests was similar for all cultivars. The additional forage from the fall cutting and winter grazing increased annual production to levels greater than those of the unharvested sub-subplots not treated with insecticide (Table II). Insecticide treated sub-subplots had larger yields at first harvest and some residual benefits from reduced larval feeding damage on subsequent harvests. However, control of alfalfa weevil larvae consistently increased seasonal total forage or alfalfa yields only in subplots left unharvested or in the herbicide treated subplots that had been grazed. Application of herbicides had little effect on seasonal total forage yield but did significantly decrease the average percentage of weeds from 1.4% to 0.1% in the forage throughout the season (Table II).

1984 (Season 2)

Peak alfalfa weevil larval populations occurred about the second week of April and averaged 0.2 and 1.0 larvae per stem in insecticide treated and untreated sub-subplots, respectively. The daily low temperatures in December of 1983 were below -13°C for more than a week resulting in a low percentage of viable weevil eggs and peak larval numbers below the economic threshold of 1.5-2.0 larvae per stem. Lower peak larval populations resulted in less feeding damage and average ratings ranged 2.3-3.0 on the scale from 1 to 9.

No cultivar consistently produced significantly greater total forage and alfalfa yields relative to other cultivars

(Table III). Harvest management treatments were not significantly different in total forage or alfalfa yields. Little stress occurred from feeding by weevil larvae and no significant differences occurred in yields among sub-subplots treated with insecticide and those that were not (Table III). Similarly, no consistent benefit in herbicide usage was documented because weed content was low in all treatments and averaged less than 5% of the first harvest forage.

The percent crude protein content was similar among cultivars and harvest management treatments (Table III). Control of weevil larvae did not consistently influence protein content. However, sub-subplots treated with herbicides did typically have significantly higher crude protein than those that were not (Table III).

A total of four harvests were made through the summer of 1984 with the last occurring 6 September. Harvesting of fall growth was done 16 November and yielded an average of 0.6 Mg/ha in both the fall harvested and winter grazed treatments. Total forage and alfalfa yields were similar among cultivars and harvest management treatments (Table IV). Control of alfalfa weevil larvae did not consistently increase annual forage yield because of low larval populations. The seasonal average percentage of weeds was less than 4% and contributed little to seasonal forage production (Table IV).

1985 (Season 3)

On 3 April 1985, the entire research area was accidentally oversprayed with methyl parathion by an aerial applicator prior to collection of the first larval samples. Applications of carbofuran insecticide had been made previously to appropriate sub-subplots to eliminate larval populations. Substantial differences in the extent of defoliation of sub-subplots which had not been sprayed with carbofuran and those sprayed were evident. On the damage rating scale, the unsprayed plots were rated at 4 to 5 while those that had been intentionally sprayed were rated 2. Larval populations monitored in a nearby insecticide evaluation 8 days prior to the overtreatment indicated that third and fourth instar larval populations were quickly approaching the economic threshold of 1.5-2.0 larvae per stem. Undoubtedly, yield reductions in untreated sub-subplots would have been greater had larvae completed development (Table V).

The weed component had become more evident especially in OK08 where sub-subplots not treated with herbicides averaged ca. 19% weeds in forage of the first crop. The sub-subplots of OK08 treated with herbicides as well as all sub-subplots of WL318 and Arc averaged less than 10% weed content. Alfalfa yields in OK08 were generally lower than the other cultivars particularly in the sub-subplots not treated with insecticide (Table V). Alfalfa yields of Arc may have been greater due to some tolerance to alfalfa weevil feeding.

Neither harvesting in late fall nor winter grazing resulted in total forage or alfalfa yields significantly different from the unharvested subplots. Larval feeding damage in the first crop or perhaps some residual effects of past years' damage was sufficient for some yield differences. This result occurred consistently in OK08 which has no tolerance for weevil feeding. Crude protein content of the first cutting in 1985 averaged 16.8% with little difference among cultivar, harvest, or pesticide treatments.

The percentage of weed content of forage from the remaining four harvests in 1985 averaged less than 5% in WL318 and Arc. In OK08, all but the fall harvested sub-subplots not treated with herbicides averaged ca. 8% weed content while in those particular sub-subplots the weed content was more than 20%.

Unharvested subplots were last cut 13 September and fall harvesting on 8 November yielded ca. 0.8 Mg/ha of forage. Comparable amounts of forage were consumed by winter grazing. Seasonal total forage yield was generally not different among cultivars (Table VI). However, seasonal alfalfa yield was typically lower in OK08 than the other cultivars due to higher weed content. Neither harvesting in fall nor winter grazing reduced seasonal total forage or alfalfa yields relative to the unharvested treatment. In OK08, however, fall harvested sub-subplots not treated with herbicides yielded significantly less alfalfa than the winter grazed treatment (Table VI).

Even though the alfalfa weevil was accidentally controlled in all plots in spring, significantly larger alfalfa yields resulted in many instances where weevil larvae had been controlled in previous years (Table VI). Control of weeds with herbicides did not consistently increase seasonal total forage yield but seasonal alfalfa yield was generally higher than in those sub-subplots where herbicides had not been applied (Table VI). Relative to the herbicides plus insecticide combination, alfalfa yield loss due to combined alfalfa weevil and weed infestations in unsprayed sub-subplots was comparable to the sum of losses caused by each pest type individually.

1986 (Season 4)

The occurrence of peak alfalfa weevil larval populations was about 11 March 1986 in subplots that had been harvested in fall or left unharvested through winter and about 10 days later in subplots that were grazed during winter. Carbofuran application was successful in maintaining peak populations in sprayed sub-subplots below 1.5 larvae per stem. Peak larval densities averaged 5.7 and 6.3 per stem in fall harvested and unharvested subplots, respectively, while those in winter grazed sub-subplots averaged only 4.4 per stem. Little larval feeding damage was evident in the sub-subplots treated with insecticide but untreated sub-subplots had ratings of ca. 4.1 in the winter grazed subplots and 4.5-4.7 in the other harvest management treatments.

Total forage yield at first harvest was similar among cultivars. However, alfalfa yield was substantially lower in all treatment combinations with OK08 than WL318 and Arc. The percentage of weeds in the forage of OK08 averaged 83.5% in unsprayed sub-subplots and 47.6% in the insecticide only treatment (Table VII). Total forage yield, alfalfa yield, and the percentage of weeds in the forage were typically not significantly different among harvest management treatments. Grazing in winter did not reduce forage production at first harvest relative to alfalfa left unharvested through winter (Table VII).

Control of weevil larval populations resulted in significantly higher total forage yield in all cultivar by harvest management combinations (Table VII). Alfalfa yield was also significantly increased when larvae were controlled. The percentage of weeds in the forage was significantly lower when weevil populations were suppressed allowing alfalfa plants to compete more effectively with weeds. Herbicide applications did not consistently increase total forage yield but alfalfa yield was significantly larger when weeds were controlled (Table VII). Relative to sub-subplots where both pest types were controlled, combined alfalfa weevil and weed infestations in unsprayed sub-subplots resulted in losses comparable to the sum of losses caused by each pest type individually.

Crude protein content of the forage at first harvest averaged ca. 17.5% and was not consistently lower in OK08 even though the percentage of weeds was higher than in other cultivars. Harvest management treatments were not significantly different in percentage crude protein. Control of alfalfa weevils did not generally increase protein levels but controlling weeds did.

Total forage and alfalfa yields of the third cutting made 10 July continued to be typically significantly lower in OK08 than the other cultivars (Table VIII). Harvest management treatments were relatively consistent with respect to total forage and alfalfa yields and the percentage of weeds in the resulting forage. Control of alfalfa weevil larval populations each spring resulted in significantly greater total forage and alfalfa yields than where insecticide was not applied (Table VIII). Similarly, consistent management of weeds resulted in significantly greater alfalfa yield than in unsprayed sub-subplots. Unsprayed sub-subplots with a high weed component and residual effects of alfalfa weevil feeding damage yielded 0.9 Mg/ha less alfalfa than plots treated with herbicides plus insecticide.

The percent crude protein of the third alfalfa crop of 1986 showed little difference among cultivars (Table IX). Though statistical differences existed in percent crude protein among harvest management treatments and insecticide levels, no consistent trend was evident. Control of weeds did result in significantly higher protein than in the forage from plots not treated with herbicides.

A total of five harvests were made in 1986. Fall cutting on 8 November yielded 0.9 and 0.5 Mg/ha total forage and alfalfa forage, respectively. Seasonal total forage and alfalfa yields of OK08 were generally significantly lower than other cultivars (Table X). Seasonal alfalfa yield from unsprayed sub-subplots was less than the alfalfa production from the first cutting only in 1983. The weed competition was also significantly higher in OK08 as had been the case at each harvest. Seasonal total forage yield was not reduced by fall harvesting or winter grazing relative to alfalfa left unharvested through winter. However, seasonal alfalfa yield tended to be significantly less in fall harvested subplots than those grazed in winter (Table X). Control of alfalfa weevil larvae in spring resulted in significantly greater total forage and alfalfa yields than where weevils were not controlled. Seasonal total forage yield was not consistently changed by weed control but seasonal alfalfa yield was significantly greater in those sub-subplots treated with herbicides (Table X). Combined alfalfa weevil and weed infestations in unsprayed sub-subplots resulted in 6.7 Mg/ha lower alfalfa yield than the herbicides plus insecticide combination.

The average percentage of weeds in forage was significantly decreased by control of alfalfa weevils or weeds. The effects of the various treatment combinations became quite evident during 1986. The value of controlling both weeds and weevils is that this treatment combination generally resulted in higher alfalfa yields and lower weed content than controlling neither pest type (ie. WL318 unharvested and winter grazed subplots).

1987 (Season 5)

The occurrence of peak alfalfa weevil larval populations was late March in 1987. Carbofuran treated sub-subplots attained an average peak density of 1.8 larvae per stem for a brief period but were not damaged appreciably. Populations of 6.5-7.2 per stem occurred in sub-subplots not treated with insecticide. Winter grazed subplots attained average peak larval populations of 5.0 per stem compared to 7.4 and 8.3 per stem in the fall harvested and unharvested treatments, respectively. Feeding damage ratings in fall harvested and unharvested sub-subplots not treated with insecticide were 3.2-3.5 and only slightly lower in subplots that had been grazed in winter (2.8); all are generally lower than in previous years.

Virtually no alfalfa was left in sub-subplots of OK08 not treated with insecticide and this cultivar had lower total forage and alfalfa yields than the others (Table XI). Lower larval densities resulted in less weevil feeding damage in winter grazed subplots and in several instances, significantly greater total forage and alfalfa yields than in the unharvested or fall harvested treatments, particularly where carbofuran was not applied (Table XI). Control of alfalfa weevil larval populations resulted in significantly greater total forage and alfalfa yields than those sub-subplots where the weevil was not controlled (Table XI). Similarly, control of weeds resulted in a significantly higher alfalfa yield than in sub-subplots where weeds were not managed. Control of both weeds and alfalfa weevils resulted in 2.8 Mg/ha more alfalfa forage than unsprayed plots with combined pest stress (Table XI).

Alfalfa yield of OK08 at third harvest was again significantly lower than the other cultivars (Table XII). Total forage yield, alfalfa yield, and the percentage of weeds were not generally significantly different among harvest management treatments (Table XII). Control of weevil larvae continued to typically result in significantly greater total forage and alfalfa yields than sub-subplots not treated with insecticide. Similarly, alfalfa yield was significantly greater in sub-subplots treated with herbicides than in those that were not (Table XII). The percentage of weeds in the forage was also significantly lower when either insecticide or herbicides were utilized.

A total of four harvests were made in 1987 before the study was terminated on 26 August. The means presented in Table XIII are seasonal totals for four harvests only. The cultivar OK08 continued to produce significantly lower total forage and alfalfa yields than the other cultivars as well as have the greatest percentage of weeds in the resulting forage (Table XIII). Little difference in either total forage or alfalfa yields existed between WL318 and Arc. Harvesting in late fall or grazing in winter still did not reduce seasonal total forage or alfalfa yields relative to alfalfa left unharvested through winter and there was generally no significant difference among harvest management treatments (Table XIII). The average percentage of weeds in the forage of 1987 was typically not significantly different among harvest management treatments. Seasonal alfalfa yield was significantly increased by control of larval populations with insecticide (Table XIII). Seasonal total forage yield was not consistently increased by treatment with herbicides but seasonal alfalfa yield was (Table XIII). As in 1986, best alfalfa yields resulted from the herbicides plus insecticide combination and poorest where both pest types were not controlled.

1983-1987 Study totals

Total forage yield from 1983 through 1987 was significantly lower in OK08 than in the other cultivars except in fall harvested and unharvested sub-subplots treated with herbicides plus insecticide (Table XIV). The forage harvested in fall or grazed in winter accounted for 3.6 and 3.2 Mg/ha of total forage and alfalfa yields, respectively. When yield was considered without the weed component, OK08 produced significantly less than the other cultivars over the 5 year period in all treatment combinations (Table XIV). Neither harvesting in late fall nor grazing in winter reduced overall total forage or alfalfa yields relative to alfalfa left unharvested through winter (Table XIV). Control of alfalfa weevil larval populations resulted in consistently higher total forage and alfalfa yields than were achieved without this treatment, irrespective of cultivar, harvest treatment, or use of herbicides. Overall total forage yield was not consistently increased by treatment with herbicides (Table XIV). However, alfalfa yield averaged significantly less in sub-subplots not treated with herbicides. Relative to the pest free type environment of the herbicides plus insecticide combination, total forage and alfalfa yields over the 5 year period were 7.1 and 16.9 Mg/ha less in unsprayed sub-subplots with combined alfalfa weevil and weed stress, respectively.

Stem density

The alfalfa stem densities prior to first harvest in 1983 ranged from 26.8 to 34.2 stems/0.1 m^2 and were not consistently different among the various treatment combinations (Table XV). By first harvest of 1984, stem densities were lower in all treatment combinations and ranged from 21.1 to 26.5 stems/0.1 m^2. By 1985, there were significant reductions in stem densities had occurred in OK08 compared to the other cultivars prior to first harvest in 1985 (Table XV). Subplots that had been grazed during winter typically had significantly greater numbers of stems/0.1 m^2 than those that had been harvested in fall. The unharvested treatment was generally similar in stem density to the fall harvested subplots but frequently significantly less than the winter grazed subplots. Stem density in 1985 was not consistently reduced by alfalfa weevil or weed infestations (Table XV).

Stem density continued to decline in all treatment combinations through 1985. Seasonal rainfall for 1985 and 1986 averaged 33.7 and 41.6 cm above the 36 year average of 77 cm/yr, respectively (Appendix A, Table I). The additional precipitation accelerated stand decline especially in OK08 which has no resistance to root rotting diseases. Prior to first harvest in 1986, the number of stems/0.1 m^2 in OK08 was usually significantly less than in WL318 and Arc (Table XVI). Neither harvesting in late fall nor winter grazing resulted in reduced stand density relative to alfalfa left unharvested through winter. In fact, winter grazed subplots occasionally had significantly more stems/0.1 m^2 than the unharvested subplots (Table XVI). Lack of alfalfa weevil control resulted in significantly fewer stems/0.1 m^2 than sub-subplots treated with insecticide. Weed management with herbicides generally resulted in significantly more stems than in sub-subplots not treated with herbicides. Relative to the herbicides plus insecticide combination, the unsprayed sub-subplots infested with both weeds and alfalfa weevils averaged 7.6 stems/0.1 m^2 less (Table XVI). This clearly indicated for the first time in the study the synergistic effects of pest combinations on stem density.

Stem densities prior to third harvests in 1986 indicated continued stand decline in OK08 relative to the other cultivars (Table XVI). Stem densities were similar among harvest management treatments at third harvest and application of herbicides did not provide consistent help for maintaining stem densities (Table XVI). Control of weevil larvae resulted in significantly more stems/0.1 m^2 than those not treated with insecticide. However, combined pest stress in the unsprayed sub-subplots resulted in 2.8-5.4 fewer stems/0.1 m^2 than the herbicides plus insecticide combination, a reduction comparable to the sum of alfalfa stem reduction from the insecticide only and herbicides only treatments.

The number of stems/0.1 m^2 prior to first harvest in 1987 was not significantly different among cultivars even though OK08 had as few as 1.3/0.1 m^2 (Table XVII). Subplots that had been grazed during winter typically had significantly more stems/0.1 m^2 than both fall harvested and unharvested subplots. Control of weevil larvae usually resulted in significantly more stems/0.1 m^2 than sub-subplots not sprayed with insecticide (Table XVII). Relative to herbicides plus insecticide combination, 6.5 fewer stems/0.1 m^2 were present in unsprayed sub-subplots with combined alfalfa weevil and weed infestations (Table XVII).

The number of stems/0.1 m^2 at third harvest (14 July 1987) was again generally significantly less in OK08 than in the other cultivars (Table XVII). Stem densities were generally not significantly different among harvest management treatments. Insecticide treated sub-subplots contained significantly more stems/0.1 m^2 than those not treated with insecticide. The number of stems/0.1 m^2 in sub-subplots treated with herbicides was typically significantly greater than the sub-subplots not sprayed with herbicides (Table XVII). Compared to the herbicides plus insecticide combination, unsprayed sub-subplots contained ca. 5.8 fewer stems/0.1 m^2 at third harvest.

Alfalfa plants were undercut in September of 1987 and root counts typically indicated significantly more alfalfa plants/1 m^2 in WL318 and Arc than in OK08 (Table XVIII). After 5 years, neither harvesting in late fall nor grazing in winter had reduced the numbers of alfalfa plants/1 m^2 relative to subplots left unharvested through winter. Control of weevil larvae resulted in significantly more alfalfa plants/1 m^2 than the unsprayed or herbicides only sub-subplots. Control of weeds with herbicides usually resulted in significantly more plants/1 m^2 than the sub-subplots not sprayed or treated with insecticide only. In the untreated sub-subplots with combined alfalfa weevil and weed infestations, plant populations averaged ca. 23.0/1 m^2 less than what were present in the herbicides plus insecticide combination where both pest types were controlled (Table XVIII). Root weights per plant averaged ca. 4.5 g and were not consistently different among any treatment combinations.

Discussion

Weed content of forage and alfalfa stem densities were similar among all treatment combinations during 1983 and 1984 and little difference in forage production caused by treatment effects was evident. When significant differences in stem density developed among cultivars in 1985 due to a combination of treatment effects and an abundance of precipitation that enhanced root diseases, substantial differences in yield began to develop. In 1985, seasonal forage production in OK08 averaged 1.4 Mg/ha less than the other cultivars. However, consistently significant differences in seasonal yields did not develop until 1986. The value of planting improved cultivars such as WL318 and Arc became quite evident during the last 2 years of the study. Stem densities of OK08 averaged ca. 5-8 stems/0.1 m^2 less and seasonal alfalfa yields ca. 5.0-6.0 Mg/ha less than the other cultivars during 1986 and 1987. Additionally, the weed content of the forage in WL318 and Arc was 25-35% less than that in OK08. Overall total forage and alfalfa yields for 1983 through 1987 were 9.0 and 15.6 Mg/ha less in OK08 than the other cultivars.

Final plant density determined at termination of the study in September 1987 was ca. 22 plants/1 m^2 greater in WL318 and Arc than OK08. The decline in plant density in OK08 probably began to develop in 1985 and resulted in continued reduction in alfalfa yields and increased weed encroachment and competition with remaining alfalfa plants.

Neither harvesting in fall nor winter grazing reduced total forage or alfalfa yields for individual harvests or seasonal yields throughout the study relative to alfalfa left unharvested through winter. Hanley et al. (1964) in England documented that grazing cattle on alfalfa after fall growth had been killed by frost but before late March did not reduce seasonal forage yield. Sholar et al. (1983) in Oklahoma also reported that seasonal forage yield was not reduced by cutting in fall. Only in 1983 did fall harvesting result in significantly larger seasonal total forage and alfalfa yields (1.5 Mg/ha more forage) than unharvested subplots. In that year, 1.1 Mg/ha of alfalfa was harvested in late fall or available for grazing. In subsequent years, total forage and alfalfa yields from these harvest management treatments produced less than 1.0 Mg/ha and contributed little to seasonal forage production. The percentage of weeds in the forage was not consistently different among harvest management treatments except in OK08 where fall harvested subplots tended to have higher weed content than the other harvest management treatments by third harvest of 1985.

Stand retention was similar among harvest management treatments and, though significant differences did occur, no consistent pattern resulted. Final plant density indicated that neither fall harvesting nor winter grazing were detrimental to stand longevity relative to alfalfa left unharvested through winter. Sholar et al. (1983) indicated that fall cutting date was not a significant factor in influencing stand persistence.

Crude protein content of forage was not consistently affected by cultivar, harvest management, or weevil management treatments. Berberet and McNew (1986) reported that feeding damage caused by weevil larvae did not necessarily reduce protein content of plant tissues because plant development was slowed resulting in higher stem protein than in older plants. This phenomenon masked protein loss due to leaf consumption. However, control of weeds with herbicides generally did result in a higher percentage of protein than the forage from the weed infested treatments.

Reduction of first harvest total forage and alfalfa yields was less than 0.6 Mg/ha in 1983 through 1985 due to infestations of alfalfa weevils or weeds relative to control of both pest types. At first harvest in 1986 and 1987, total forage and alfalfa yields were reduced ca. 1.0-1.4 Mg/ha due to infestations of alfalfa weevils each year relative to the herbicides plus insecticide treatment. Control of weeds throughout the study did slightly increase total forage yield at first harvest in later years. Combined alfalfa weevil and weed infestations decreased total forage yield by 0.7 Mg/ha, while alfalfa yield was reduced almost 3.0 Mg/ha, relative to the herbicides plus insecticide combination where both pest types were managed. Berberet et al. (1987) and Norris et al. (1984) also documented greatest yield loss in plots infested with both weeds and alfalfa weevils. In 1987, the loss of total forage and alfalfa yields in winter grazed subplots due to combined pest stress (0.6 Mg/ha) was about half that of the other harvest management treatments, relative to the treatment where both pest types were controlled. Winter grazing more effectively reduced larval populations allowing better plant growth and development.

Decreases in seasonal total forage and alfalfa yields due to infestations of weevils, weeds, or both were typically less than 1.0 Mg/ha from 1983 to 1985. In 1986 and 1987, the effects of pest management throughout the study became more evident as reductions in stem density and yield due to pest infestations increased substantially. Alfalfa weevil infestation reduced seasonal total forage yields 1.5-2.7 Mg/ha while seasonal alfalfa yields were reduced 2.1-3.6 Mg/ha, relative to the herbicides plus insecticide combination. Seasonal total forage yields were increased little due to weed control throughout the study but residual effects on seasonal alfalfa yields were 2.0-4.5 Mg/ha lower in the weed infested treatment by 1986, relative to the sub-subplots where both pest types were managed. Infestations of both weeds and weevils reduced seasonal total forage yield up to 4.5 Mg/ha by 1987 and reduced alfalfa yield as much as 8.1 Mg/ha. Although the same trends in yield loss occurred, greater losses occurred in this study than in that of Berberet et al. (1987) probably due to higher weed infestations.

Infestations with either weeds or weevil larvae resulted in up to 5.4 stems/0.1 m^2 fewer than from controlling both pest types while as many as 8.6 stems/0.1 m^2 fewer resulted where neither pest type was controlled. This was consistent among all harvest management treatments. Berberet et al. (1987) reported virtual loss of an alfalfa stand after 2-4 years due to infestation of both weeds and weevils.

Overall total forage yields from 1983 to 1987 were 5.6 and 1.8 Mg/ha lower when weevils or weeds were left uncontrolled, respectively. Overall alfalfa yields were 7.5 and 7.3 Mg/ha lower when either weevils or weeds were not managed, relative to the treatment where both pest types were controlled. The loss due to combined pest stress was equal to or greater than the sum of the losses caused by each pest type individually.

Final plant densities at the termination of the study averaged ca. 8.5/1 m^2 lower due to alfalfa weevil infestation and 14.1/1 m^2 lower due to weed competition relative to the treatment where both pest types were managed. About 23 plants/1 m^2 fewer resulted from combined stress caused by infestations of weeds and alfalfa weevils as compared to the herbicides plus insecticide combination. The loss in plant density in the unsprayed treatment with infestations of both pest types was comparable to the sum of the losses caused by each pest type individually.

In conclusion, forage production and stand retention of the unimproved cultivar OK08 was comparable to the other cultivars for the first 3 years of the study but degenerated rapidly in the last 2 years of the study due to high weed infestations in all treatment combinations. Relative to alfalfa left unharvested through winter, neither harvesting in late fall nor winter grazing reduced forage production or stand persistence after 5 years. Though additional forage was available by harvesting in late fall and grazing in winter, this production was generally insufficient to substantially increase seasonal yield relative to the unharvested treatment. Infestations of weeds and alfalfa weevils reduced alfalfa yields and accelerated stand decline. Control of weevil larvae resulted in greater alfalfa production and reduced weed infestations by removing stress from alfalfa plants and allowing better competition with weedy species. Control of weeds did not always increase seasonal forage yields but did increase the alfalfa component of the resulting forage. Management of weeds or alfalfa weevils reduced stand loss relative to unsprayed alfalfa allowing the stand to remain in production for a longer period of time which became more important in the later years of stand life.

References Cited

Beard, D. F., & I. I. Kawaguchi. 1978. Registration of WL311 and WL318 alfalfa cultivars. (Reg. Nos. 85 86). Crop Sci. 18: 523.

Berberet,R. C., R. D. Morrison, & K. M. Senst. 1981. Impact of the alfalfa weevil, Hypera postica (Gyllenhal), on forage production in nonirrigated alfalfa in the southern plains. J. Kansas Entomol. Soc. 60: 1185.

Berberet, R. C. & R. W. McNew. 1986. Reductions in yield and quality of leaf and stem components of alfalfa forage due to damage by larvae of Hypera postica (Coleoptera: Curculionidae). J. Econ. Entomol. 79: 212-218.

Berberet, R. C., J. F. Stritzke, & A. K. Dowdy. 1987. Interactions of alfalfa weevil (Coleoptera: Curculionidae) and weeds in reducing yield and stand of alfalfa. J. Econ. Entomol. 80: 1306-1313.

Cords, H. P. 1973. Weeds and alfalfa hay quality. Weed Sci. 21: 400-401.

Devine, T. E., R. H. Ratcliffe, C. M. Rinker, D. K. Barnes, S. A. Ostazeski, T. H. Busbice, C. H. Hanson, J. A. Schillinger, G. R. Buss, & R. W. Cleveland. 1975. Registration of Arc alfalfa. (Reg. No. 76). Crop Sci. 15: 97.

Dively, G. P., Jr. 1970. Overwintering alfalfa weevil eggs in three stages of alfalfa growth in New Jersey. Ann. Entomol. Soc. Amer. 63: 1213-1216.

Dowdy, A. K., R. C. Berberet, & J. L. Caddel. 1986. Population densities of alfalfa weevil, Hypera postica ((Coleoptera: Curculionidae), with varied fall planting dates for alfalfa. J. Econ. Entomol. 79: 790-796.

Gibson, C. W. D., H. C. Dawkins, V. K. Brown, & M. Jepsen. 1987a. Spring grazing by sheep: effects on seasonal changes during early old field succession. Vegetatio 70: 33-43.

Gibson, C. W. D., V. K. Brown, & M. Jepsen. 1987b. Relationship between the effects of insect herbivory and sheep grazing on seasonal changes in an early successional plan community. Oecologia 71: 245-253.

Hanley, F., W. J. Ridgman, & J. D. Whitear. 1964. The effect of date of winter grazing on the yield of a lucerne-grass ley. J. Agric. Sci. 62: 281-284.

Norris, R. F., W. R. Cothran, & V. E. Burton. 1984. Interactions between winter annual weeds and Egyptian alfalfa weevil in Alfalfa. J. Econ. Entomol. 77: 43-52.

SAS Users guide: statistics, version 5 edition. 1985. SAS Institute, Cary, North Carolina. 957p.

Sholar, R., J. Caddel. L. Rommann, J. Stritzke, G. Johnson, D. Schwab, S. Coppock, R. Berberet, E. Williams, W. Bowers, & T. Shaklee. 1982. Alfalfa production and pest management in Oklahoma. Oklahoma St. Univ. Coop. Ext. Circ. E-826.

Steel, R. G. D. & J. H. Torrie. 1980. Principles and Procedures of Statistics: a Biometric Approach. 2nd Ed. McGraw-Hill Book Co., Inc. New York.

Temme, D. G., R. G. Harvey, R. S. Fawcett, & A. W. Young. 1979. Effects of annual weed control on alfalfa forage quality. Agron. J. 71: 51-54.

TABLE I

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 12 MAY 1983, SEASON 1

All cultivars	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Total forage yield (Mg/ha)			
No insect.	5.3 ± 0.2	4.8 ± 0.3	4.7 ± 0.2	4.5 ± 0.2	5.1 ± 0.2	4.7 ± 0.2
Insecticide	5.6 ± 0.2	5.1 ± 0.2	5.1 ± 0.1	4.8 ± 0.2	5.5 ± 0.2	5.0 ± 0.2
			Alfalfa yield (Mg/ha)			
No insect.	5.1 ± 0.2	4.8 ± 0.3	4.4 ± 0.2	4.4 ± 0.2	4.8 ± 0.2	4.7 ± 0.2
Insecticide	5.4 ± 0.2	5.1 ± 0.2	5.0 ± 0.1	4.8 ± 0.2	5.3 ± 0.2	4.9 ± 0.2
			Percent crude protein			
No insect.	17.0 ± 0.6	17.4 ± 0.7	17.6 ± 0.7	17.1 ± 0.9	17.3 ± 0.7	19.1 ± 0.8
Insecticide	16.4 ± 0.9	17.8 ± 0.8	17.8 ± 0.8	17.6 ± 0.5	17.0 ± 0.9	17.6 ± 0.7

	Total	Alfalfa	% protein
L.S.D. for harvest management=	0.8	0.8	1.9
L.S.D. for pesticides=	0.2	0.2	0.8

TABLE II

SEASONAL HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1983, SEASON 1

All cultivars	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Total forage yield (Mg/ha)			
No insect.	16.6 ± 0.4	15.9 ± 0.5	15.1 ± 0.4	15.8 ± 0.4	14.3 ± 0.3	14.1 ± 0.3
Insecticide	16.4 ± 0.5	16.2 ± 0.6	15.8 ± 0.4	15.9 ± 0.3	15.6 ± 0.6	15.2 ± 0.5
			Alfalfa yield (Mg/ha)			
No insect.	16.4 ± 0.5	15.9 ± 0.5	14.8 ± 0.4	15.8 ± 0.4	14.0 ± 0.3	14.1 ± 0.3
Insecticide	16.3 ± 0.5	16.2 ± 0.6	15.6 ± 0.4	15.9 ± 0.3	15.3 ± 0.5	15.2 ± 0.5

	Total yield	Alfalfa yield
LSD for harvest management=	1.6	1.6
LSD for pesticide=	0.4	0.4

TABLE III

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x} \pm SE$) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 8 MAY 1984, SEASON 2

All cultivars	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
No insect.	5.9 ± 0.5	5.1 ± 0.1	5.7 ± 0.2	5.6 ± 0.3	5.7 ± 0.2	5.6 ± 0.1
Insecticide	5.3 ± 0.2	5.4 ± 0.2	5.5 ± 0.2	5.7 ± 0.1	5.9 ± 0.2	5.6 ± 0.2
			Alfalfa yield (Mg/ha)			
No insect.	5.7 ± 0.5	5.1 ± 0.3	5.6 ± 0.2	5.6 ± 0.3	5.5 ± 0.2	5.6 ± 0.1
Insecticide	5.3 ± 0.2	5.4 ± 0.2	5.4 ± 0.2	5.7 ± 0.1	5.8 ± 0.2	5.6 ± 0.2
			Percent crude protein			
No insect.	20.7 ± 0.3	19.9 ± 0.3	20.3 ± 0.4	21.7 ± 0.7	18.8 ± 0.9	20.4 ± 0.7
Insecticide	19.5 ± 0.7	21.3 ± 0.6	20.2 ± 0.2	20.1 ± 1.0	19.2 ± 1.1	20.6 ± 0.5

	Total	Alfalfa	% protein
L.S.D. for harvest management=	1.0	1.0	2.7
L.S.D. for pesticides=	0.2	0.2	0.6

TABLE IV

SEASONAL HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1984, SEASON 2

All cultivars	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Total forage yield (Mg/ha)			
No insect.	19.9 ± 0.8	19.0 ± 0.7	19.4 ± 1.0	19.3 ± 0.7	18.1 ± 0.6	18.3 ± 0.5
Insecticide	19.7 ± 0.7	19.3 ± 0.6	18.2 ± 0.5	19.4 ± 0.5	19.0 ± 0.5	19.3 ± 0.6
			Alfalfa yield (Mg/ha)			
No insect.	19.5 ± 0.8	19.0 ± 0.7	19.4 ± 1.0	19.3 ± 0.7	17.9 ± 0.7	18.3 ± 0.5
Insecticide	19.5 ± 0.7	19.3 ± 0.6	18.2 ± 0.5	19.4 ± 0.5	19.0 ± 0.5	19.2 ± 0.6

	Total yield	Alfalfa yield
LSD for cultivar=	2.9	3.1
LSD for harvest management=	3.1	3.1
LSD for pesticide=	0.7	0.7

TABLE V

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 3 MAY 1985, SEASON 3

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	5.2 ± 0.4	5.0 ± 0.4	5.3 ± 0.4	5.3 ± 0.2	5.2 ± 0.1	5.7 ± 0.4
Insecticide	5.8 ± 0.1	5.6 ± 0.2	6.0 ± 0.5	6.0 ± 0.1	6.3 ± 0.6	5.6 ± 0.2
Arc						
No insect.	6.8 ± 0.3	6.4 ± 0.2	6.6 ± 0.4	6.4 ± 0.3	6.0 ± 0.2	6.2 ± 0.2
Insecticide	6.2 ± 0.1	6.4 ± 0.6	6.8 ± 0.7	6.4 ± 0.2	5.8 ± 0.5	7.0 ± 0.3
OK08						
No insect.	5.0 ± 0.3	4.6 ± 0.2	4.7 ± 0.3	4.7 ± 0.4	4.4 ± 0.5	5.2 ± 0.5
Insecticide	4.8 ± 0.3	5.8 ± 0.5	5.2 ± 0.4	5.9 ± 0.4	5.0 ± 0.7	5.6 ± 0.5
			Alfalfa forage yield (Mg/ha)			
WL318						
No insect.	4.8 ± 0.6	4.9 ± 0.4	4.8 ± 0.8	5.3 ± 0.2	4.9 ± 0.1	5.6 ± 0.4
Insecticide	5.7 ± 0.1	5.6 ± 0.2	5.9 ± 0.5	5.9 ± 0.1	5.9 ± 0.5	5.5 ± 0.2
Arc						
No insect.	5.5 ± 0.8	6.3 ± 0.2	6.5 ± 0.4	5.8 ± 0.8	5.1 ± 0.9	5.5 ± 0.5
Insecticide	5.3 ± 0.7	6.3 ± 0.6	6.7 ± 0.7	6.3 ± 0.2	5.8 ± 0.5	6.9 ± 0.2
OK08						
No insect.	3.1 ± 0.9	4.2 ± 0.3	3.9 ± 0.7	4.4 ± 0.5	3.9 ± 0.4	4.7 ± 0.6
Insecticide	4.0 ± 0.6	5.5 ± 0.5	4.6 ± 0.9	5.6 ± 0.5	4.5 ± 1.0	5.0 ± 0.9

TABLE V (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percent crude protein			
No insect.	16.8 ± 0.7	16.2 ± 0.6	17.3 ± 0.7	16.5 ± 0.5	16.7 ± 0.6	17.0 ± 0.8
Insecticide	16.1 ± 0.6	16.9 ± 0.6	17.5 ± 0.5	17.8 ± 0.7	16.4 ± 0.7	16.3 ± 0.5

	Total	Alfalfa	% protein
L.S.D. for cultivar=	1.1	1.5	-
L.S.D. for harvest management=	0.9	1.2	2.6
L.S.D. for pesticides=	0.2	0.2	0.7

TABLE VI

SEASONAL HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1985, SEASON 3

	Fall cut		Winter grazed		Unharvested	
Cultivar	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Total forage yield (Mg/ha)			
WL318						
No insect.	23.0 ± 0.9	22.1 ± 0.4	21.9 ± 0.3	21.6 ± 0.8	21.0 ± 1.0	21.5 ± 1.2
Insecticide	22.5 ± 1.1	22.2 ± 1.1	23.6 ± 0.6	22.9 ± 0.4	22.9 ± 0.9	22.4 ± 0.8
Arc						
No insect.	23.1 ± 0.4	22.6 ± 0.7	22.4 ± 0.9	23.4 ± 1.6	21.9 ± 1.6	22.2 ± 0.9
Insecticide	22.8 ± 1.0	22.8 ± 0.9	23.8 ± 1.0	22.6 ± 1.0	21.7 ± 0.9	22.9 ± 1.1
OK08						
No insect.	20.9 ± 0.5	20.8 ± 0.6	22.2 ± 1.5	20.0 ± 1.2	19.9 ± 1.5	21.1 ± 1.2
Insecticide	20.2 ± 1.1	21.6 ± 0.9	21.9 ± 0.7	23.0 ± 1.4	20.6 ± 1.3	20.9 ± 1.4
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	22.2 ± 1.0	21.9 ± 0.3	21.4 ± 0.7	21.5 ± 0.8	20.7 ± 1.1	21.4 ± 1.3
Insecticide	22.3 ± 1.1	22.0 ± 1.1	23.5 ± 0.6	22.8 ± 0.4	22.4 ± 0.8	22.2 ± 0.8
Arc						
No insect.	20.7 ± 1.2	22.1 ± 0.8	22.2 ± 1.0	22.6 ± 1.9	20.5 ± 2.2	21.3 ± 1.2
Insecticide	21.4 ± 1.5	22.5 ± 1.1	23.6 ± 1.0	22.3 ± 1.1	21.6 ± 1.0	22.6 ± 1.1
OK08						
No insect.	15.1 ± 1.6	19.2 ± 1.0	20.1 ± 2.5	17.7 ± 1.9	17.9 ± 1.7	20.0 ± 1.5
Insecticide	16.5 ± 2.9	20.2 ± 1.4	20.7 ± 1.4	22.5 ± 1.5	19.3 ± 1.6	18.5 ± 2.3

	Total yield	Alfalfa yield
LSD for cultivar=	2.7	4.0
LSD for harvest management=	2.0	2.9
LSD for pesticide=	0.4	0.6

TABLE VII

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 29 APRIL 1986, SEASON 4

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.7 ± 0.1	2.5 ± 0.1	3.1 ± 0.2	2.7 ± 0.3	3.1 ± 0.1	2.7 ± 0.2
Insecticide	4.1 ± 0.1	3.8 ± 0.3	4.2 ± 0.2	4.2 ± 0.1	4.8 ± 0.6	4.3 ± 0.2
Arc						
No insect.	3.2 ± 0.2	2.5 ± 0.1	3.2 ± 0.3	3.0 ± 0.2	3.6 ± 0.4	3.2 ± 0.1
Insecticide	4.7 ± 0.3	4.0 ± 0.2	4.6 ± 0.3	4.2 ± 0.2	4.8 ± 0.3	4.4 ± 0.2
OK08						
No insect.	2.0 ± 0.2	1.9 ± 0.5	2.2 ± 0.3	2.2 ± 0.6	3.0 ± 0.8	1.7 ± 0.5
Insecticide	3.0 ± 0.4	2.9 ± 0.1	3.5 ± 0.1	3.3 ± 0.4	3.8 ± 0.2	3.4 ± 0.3
			Alfalfa forage yield Mg/ha)			
WL318						
No insect.	1.4 ± 0.2	2.2 ± 0.1	1.9 ± 0.2	2.6 ± 0.2	1.4 ± 0.3	2.6 ± 0.2
Insecticide	2.9 ± 0.5	3.7 ± 0.3	3.6 ± 0.2	4.1 ± 0.1	3.6 ± 0.7	4.0 ± 0.3
Arc						
No insect.	1.1 ± 0.3	2.1 ± 0.1	2.1 ± 0.4	2.8 ± 0.2	1.4 ± 0.4	2.9 ± 0.2
Insecticide	3.8 ± 0.4	3.8 ± 0.2	4.1 ± 0.4	4.1 ± 0.2	3.4 ± 0.5	4.3 ± 0.2
OK08						
No insect.	0.4 ± 0.2	1.4 ± 0.4	0.4 ± 0.1	1.8 ± 0.4	0.3 ± 0.1	1.5 ± 0.3
Insecticide	1.4 ± 0.5	2.5 ± 0.2	2.2 ± 0.3	3.0 ± 0.2	1.9 ± 0.6	2.9 ± 0.4

TABLE VII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	48.5 ± 5.7	8.8 ± 3.5	38.0 ± 5.6	3.5 ± 1.7	52.8 ±11.7	5.3 ± 1.9
Insecticide	28.0 ±12.5	2.8 ± 1.1	13.0 ± 3.7	2.3 ± 0.9	27.8 ± 4.9	8.0 ± 4.7
Arc						
No insect.	66.3 ± 8.5	14.5 ± 3.7	34.3 ± 8.6	7.5 ± 3.2	60.0 ± 7.9	10.5 ± 5.4
Insecticide	20.0 ± 4.4	4.8 ± 0.9	11.5 ± 4.9	3.8 ± 1.4	28.8 ± 7.6	2.5 ± 1.0
OK08						
No insect.	80.5 ±11.9	25.0 ±10.1	81.3 ± 6.3	16.3 ± 5.1	88.8 ± 4.7	8.5 ± 4.6
Insecticide	52.8 ±11.9	12.5 ± 3.8	38.0 ± 8.8	8.5 ± 3.4	52.0 ±13.1	14.5 ± 4.8

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.6	0.9	20.2
L.S.D. for harvest management=	1.2	0.8	17.0
L.S.D. for pesticides=	0.2	0.2	3.7

TABLE VIII

THIRD HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 10 JULY 1986, SEASON 4

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.4 ± 0.2	2.8 ± 0.2	2.8 ± 0.2	2.5 ± 0.2	2.5 ± 0.3	2.5 ± 0.1
Insecticide	2.8 ± 0.1	2.8 ± 0.2	2.6 ± 0.1	3.2 ± 0.2	3.2 ± 0.3	3.0 ± 0.2
Arc						
No insect.	2.7 ± 0.4	2.3 ± 0.2	2.5 ± 0.3	2.8 ± 0.5	2.3 ± 0.3	2.4 ± 0.4
Insecticide	2.7 ± 0.3	2.7 ± 0.3	2.3 ± 0.4	2.5 ± 0.3	3.0 ± 0.2	3.0 ± 0.6
OK08						
No insect.	1.5 ± 0.4	1.7 ± 0.1	1.8 ± 0.2	2.1 ± 0.2	2.1 ± 0.3	2.2 ± 0.2
Insecticide	2.1 ± 0.2	2.5 ± 0.2	1.9 ± 0.2	2.4 ± 0.4	2.7 ± 0.2	2.5 ± 0.1
			Alfalfa forage yield (Mg/ ha)			
WL318						
No insect.	2.1 ± 0.1	2.7 ± 0.2	2.7 ± 0.2	2.5 ± 0.3	2.3 ± 0.2	2.5 ± 0.1
Insecticide	2.7 ± 0.1	2.7 ± 0.2	2.6 ± 0.1	3.2 ± 0.2	3.1 ± 0.3	3.0 ± 0.2
Arc						
No insect.	1.9 ± 0.6	2.2 ± 0.2	2.1 ± 0.3	2.8 ± 0.5	1.7 ± 0.6	2.3 ± 0.4
Insecticide	2.5 ± 0.3	2.7 ± 0.3	2.2 ± 0.3	2.4 ± 0.2	2.8 ± 0.3	3.0 ± 0.6
OK08						
No insect.	0.8 ± 0.4	0.8 ± 0.4	0.6 ± 0.2	1.7 ± 0.3	0.7 ± 0.3	1.8 ± 0.2
Insecticide	1.5 ± 0.5	1.8 ± 0.6	0.2 ± 0.3	2.2 ± 0.3	0.5 ± 0.4	2.1 ± 0.2

TABLE VIII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	10.5 ± 2.2	2.5 ± 0.5	3.5 ± 2.5	2.8 ± 2.4	10.0 ± 3.2	1.3 ± 0.8
Insecticide	3.3 ± 0.9	0.8 ± 0.5	0.8 ± 0.3	1.3 ± 0.7	1.3 ± 0.5	0.0 ± 0.0
Arc						
No insect.	33.5 ±15.4	3.8 ± 0.5	14.8 ± 3.1	1.3 ± 0.2	27.8 ±19.0	6.5 ± 3.2
Insecticide	6.3 ± 2.5	0.3 ± 0.3	3.8 ± 2.2	1.5 ± 0.6	9.0 ± 4.5	0.5 ± 0.3
OK08						
No insect.	57.3 ±21.0	56.0 ±19.6	66.8 ±16.7	19.8 ± 7.9	68.5 ±11.8	17.5 ± 7.6
Insecticide	34.8 ±18.4	31.0 ±21.6	39.8 ±13.9	7.8 ± 1.7	35.5 ±16.4	14.0 ± 5.2

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	1.0	29.9
L.S.D. for harvest management=	0.6	0.7	22.3
L.S.D. for pesticides=	0.1	0.2	5.8

TABLE IX

PERCENTAGE OF CRUDE PROTEIN ($\bar{x}$ ± SE) IN FORAGE AS INFLUENCED BY HARVEST, INSECT AND WEED MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 10 JULY 1986, SEASON 4

	Fall cut		Winter grazed		Unharvested	
Cultivar	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
WL318						
No insect.	12.9 ± 3.3	16.6 ± 0.6	16.0 ± 3.0	12.0 ± 3.0	15.7 ± 0.6	16.7 ± 0.7
Insecticide	17.2 ± 0.9	17.5 ± 0.2	17.0 ± 1.1	15.9 ± 1.5	14.2 ± 3.2	16.9 ± 0.5
Arc						
No insect.	16.3 ± 1.5	17.0 ± 0.3	17.8 ± 1.3	18.1 ± 0.7	14.4 ± 2.3	18.4 ± 1.0
Insecticide	15.1 ± 2.6	16.5 ± 2.7	18.3 ± 0.7	17.7 ± 0.9	16.3 ± 2.3	18.6 ± 0.6
OK08						
No insect.	12.8 ± 0.8	15.6 ± 1.2	12.4 ± 0.9	15.7 ± 0.4	15.2 ± 1.2	16.5 ± 0.8
Insecticide	11.6 ± 2.6	13.9 ± 1.4	16.5 ± 0.5	16.3 ± 0.8	16.1 ± 0.7	15.0 ± 0.6

LSD for cultivar= 3.9
LSD for harvest management= 1.8
LSD for pesticide= 1.1

TABLE X

SEASONAL FORAGE YIELD ($\bar{x}$ ± SE) IN ALFALFA AFTER INFESTATION BY WEEDS, ALFALFA WEEVILS, OR BOTH AND INFLUENCED BY HARVEST MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1986, SEASON 4

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Total forage yield (Mg/ha)			
WL318						
No insect.	15.5 ± 0.5	16.0 ± 0.4	16.9 ± 0.8	15.5 ± 0.5	15.6 ± 1.2	14.5 ± 0.4
Insecticide	17.0 ± 0.3	16.6 ± 1.0	16.5 ± 0.9	17.8 ± 0.4	18.0 ± 0.9	17.0 ± 1.0
Arc						
No insect.	16.3 ± 0.8	14.3 ± 0.9	16.7 ± 1.1	16.4 ± 0.8	15.7 ± 1.4	15.5 ± 0.4
Insecticide	17.9 ± 0.7	16.7 ± 0.4	17.9 ± 1.3	17.5 ± 0.6	17.6 ± 0.4	16.7 ± 1.2
OK08						
No insect.	10.8 ± 1.3	11.8 ± 0.8	12.9 ± 1.1	13.4 ± 0.9	12.6 ± 1.2	12.5 ± 0.4
Insecticide	14.6 ± 1.0	14.8 ± 1.2	15.2 ± 0.8	14.5 ± 0.9	15.8 ± 1.0	16.8 ± 1.0
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	9.8 ± 0.6	14.5 ± 0.3	13.5 ± 0.9	14.5 ± 0.9	11.1 ± 0.7	13.8 ± 0.4
Insecticide	14.3 ± 0.6	15.9 ± 1.1	15.3 ± 0.8	17.0 ± 0.3	16.1 ± 0.8	16.3 ± 1.1
Arc						
No insect.	7.7 ± 1.2	12.3 ± 0.7	11.4 ± 0.9	15.4 ± 1.0	8.9 ± 2.2	13.4 ± 1.3
Insecticide	13.5 ± 1.2	15.2 ± 0.4	15.0 ± 0.9	16.5 ± 0.5	13.8 ± 1.2	16.1 ± 1.3
OK08						
No insect.	2.6 ± 1.3	6.4 ± 1.9	3.3 ± 0.6	9.4 ± 1.2	3.5 ± 1.5	9.1 ± 1.3
Insecticide	6.9 ± 2.2	10.7 ± 1.3	8.0 ± 1.0	12.5 ± 0.6	8.9 ± 2.5	12.3 ± 1.3

TABLE X (Continued)

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Percentage of weeds			
WL318						
No insect.	37.0 ± 3.4	8.7 ± 2.0	20.3 ± 3.3	7.1 ± 3.2	28.8 ± 1.8	4.5 ± 1.6
Insecticide	15.8 ± 2.9	4.3 ± 1.8	7.4 ± 0.5	4.7 ± 1.1	10.5 ± 0.5	3.9 ± 1.3
Arc						
No insect.	53.5 ± 5.6	13.7 ± 2.2	31.8 ± 1.9	6.1 ± 1.2	44.4 ± 12.0	13.9 ± 6.3
Insecticide	25.3 ± 5.1	8.8 ± 2.7	15.8 ± 3.9	5.8 ± 1.4	21.7 ± 6.4	3.3 ± 0.8
OK08						
No insect.	77.8 ± 8.5	46.8 ± 13.2	74.1 ± 4.4	30.5 ± 6.4	74.0 ± 9.5	27.0 ± 9.9
Insecticide	55.0 ± 11.8	27.8 ± 8.9	46.8 ± 6.7	14.1 ± 1.7	45.8 ± 13.5	26.6 ± 6.7

	Total yield	Alfalfa yield	% weeds
LSD for cultivar=	2.4	3.4	16.8
LSD for harvest management=	2.1	2.4	12.7
LSD for pesticide=	0.5	0.6	2.6

TABLE XI

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 12 MAY 1987, SEASON 5

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	4.1 ± 0.3	3.8 ± 0.5	5.5 ± 0.7	5.3 ± 0.9	4.7 ± 0.7	4.2 ± 0.5
Insecticide	5.7 ± 0.4	4.7 ± 0.5	6.6 ± 0.6	5.5 ± 1.0	6.5 ± 0.3	4.9 ± 0.6
Arc						
No insect.	3.3 ± 0.2	3.4 ± 0.6	4.2 ± 0.4	4.6 ± 0.6	4.2 ± 0.3	3.3 ± 0.4
Insecticide	4.5 ± 0.6	4.6 ± 0.3	5.0 ± 0.8	4.8 ± 0.2	4.3 ± 0.3	4.8 ± 0.8
OK08						
No insect.	2.4 ± 0.4	2.3 ± 1.0	3.7 ± 0.9	3.2 ± 1.0	3.1 ± 0.6	2.5 ± 0.8
Insecticide	3.4 ± 0.9	4.1 ± 1.1	3.7 ± 0.5	4.7 ± 1.0	4.2 ± 0.9	4.0 ± 0.6
			Alfalfa forage yield (Mg/ha)			
WL318						
No insect.	1.4 ± 0.4	3.0 ± 0.5	1.7 ± 0.6	4.0 ± 1.5	1.2 ± 0.6	3.3 ± 0.8
Insecticide	3.1 ± 1.0	4.4 ± 0.6	3.3 ± 1.0	4.4 ± 1.2	3.7 ± 0.7	4.1 ± 0.4
Arc						
No insect.	1.0 ± 0.5	2.2 ± 0.2	1.4 ± 0.6	3.7 ± 0.9	0.6 ± 0.3	1.6 ± 0.5
Insecticide	2.1 ± 0.5	3.8 ± 0.3	2.9 ± 0.7	3.5 ± 0.5	2.0 ± 0.6	4.1 ± 0.5
OK08						
No insect.	0.1 ± 0.1	1.2 ± 0.8	0.2 ± 0.1	1.7 ± 0.6	0.1 ± 0.1	1.6 ± 0.7
Insecticide	0.9 ± 0.6	3.0 ± 1.2	0.6 ± 0.3	3.3 ± 1.2	1.2 ± 0.8	2.1 ± 0.9

TABLE XI (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	66.3 ± 9.4	20.0 ± 9.9	71.5 ± 7.5	24.5 ±20.9	74.3 ±12.8	23.5 ± 9.9
Insecticide	48.5 ±16.4	7.0 ± 5.4	52.5 ±12.0	21.8 ±12.0	43.5 ± 8.4	15.8 ± 6.5
Arc						
No insect.	71.8 ±14.4	28.0 ±14.5	69.0 ± 9.6	21.8 ±12.8	85.8 ± 7.0	51.5 ±16.0
Insecticide	55.5 ± 5.6	17.0 ± 5.2	43.3 ± 7.0	29.0 ± 8.1	53.8 ±12.5	11.0 ± 7.0
OK08						
No insect.	94.8 ± 1.3	49.8 ±18.8	93.0 ± 2.7	44.0 ± 9.5	95.3 ± 0.5	39.8 ±17.5
Insecticide	81.0 ± 9.1	25.8 ±15.5	83.3 ± 6.0	33.5 ±14.5	78.0 ±11.4	52.5 ±14.6

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.6	1.9	29.6
L.S.D. for harvest management=	1.2	1.5	27.9
L.S.D. for pesticides=	0.3	0.4	6.9

TABLE XII

THIRD HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 21 JULY 1987, SEASON 5

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.1 ± 0.3	3.0 ± 0.2	2.7 ± 0.1	2.5 ± 0.1	2.1 ± 0.2	2.7 ± 0.1
Insecticide	2.9 ± 0.2	2.6 ± 0.2	2.3 ± 0.2	3.2 ± 0.2	3.0 ± 0.3	2.6 ± 0.2
Arc						
No insect.	1.9 ± 0.6	2.1 ± 0.3	1.9 ± 0.4	2.0 ± 0.2	2.0 ± 0.4	2.5 ± 0.4
Insecticide	2.0 ± 0.4	2.4 ± 0.2	2.3 ± 0.3	2.4 ± 0.2	2.3 ± 0.3	2.6 ± 0.2
OK08						
No insect.	0.8 ± 0.2	1.6 ± 0.4	1.0 ± 0.2	1.9 ± 0.2	1.3 ± 0.3	1.6 ± 0.4
Insecticide	1.7 ± 0.4	2.2 ± 0.3	1.3 ± 0.4	2.4 ± 0.4	1.4 ± 0.2	1.8 ± 0.3
			Alfalfa forage yield (Mg/ha)			
WL318						
No insect.	1.2 ± 0.4	2.7 ± 0.2	1.5 ± 0.2	2.4 ± 0.2	0.9 ± 0.4	2.3 ± 0.4
Insecticide	2.6 ± 0.2	2.5 ± 0.2	1.8 ± 0.2	3.1 ± 0.2	2.5 ± 0.3	2.6 ± 0.2
Arc						
No insect.	1.5 ± 0.5	1.9 ± 0.3	1.3 ± 0.5	1.8 ± 0.2	0.8 ± 0.3	1.6 ± 0.5
Insecticide	1.4 ± 0.5	2.3 ± 0.2	1.8 ± 0.3	2.1 ± 0.3	1.5 ± 0.4	2.5 ± 0.2
OK08						
No insect.	0.2 ± 0.2	0.8 ± 0.5	0.2 ± 0.2	0.6 ± 0.2	0.1 ± 0.1	0.6 ± 0.4
Insecticide	0.5 ± 0.5	1.3 ± 0.7	0.6 ± 0.3	2.0 ± 0.5	0.6 ± 0.3	1.0 ± 0.5

TABLE XII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	45.8 ±16.4	7.3 ± 2.0	41.0 ± 8.9	3.3 ± 0.9	60.3 ±15.7	18.3 ±11.0
Insecticide	11.0 ± 2.5	3.8 ± 1.1	21.0 ± 4.1	2.0 ± 0.4	15.5 ± 7.3	2.8 ± 0.5
Arc						
No insect.	27.5 ± 8.3	10.0 ± 3.9	41.3 ±15.7	8.5 ± 3.3	62.0 ±14.1	41.5 ±15.8
Insecticide	37.8 ±11.0	5.0 ± 2.3	22.3 ± 6.6	14.3 ± 8.6	37.5 ± 7.7	3.5 ± 0.9
OK08						
No insect.	86.8 ±11.9	63.3 ±19.5	85.0 ±11.4	64.3 ±14.7	92.3 ± 2.2	70.0 ±15.0
Insecticide	80.5 ±16.5	48.0 ±23.5	67.8 ±15.6	19.8 ± 7.3	54.0 ±17.9	53.8 ±20.3

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	1.0	32.6
L.S.D. for harvest management=	0.7	0.8	26.5
L.S.D. for pesticides=	0.2	0.2	6.0

TABLE XIII

SEASONAL FORAGE YIELD ($\bar{x}$ ± SE) IN ALFALFA AFTER INFESTATION BY WEEDS, ALFALFA WEEVILS, OR BOTH AND INFLUENCED BY HARVEST MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1987, SEASON 5

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Total forage yield (Mg/ha)			
WL318						
No insect.	10.9 ± 0.9	13.5 ± 0.6	13.1 ± 0.7	14.5 ± 1.6	11.3 ± 1.2	13.2 ± 0.6
Insecticide	15.1 ± 1.0	14.3 ± 1.0	15.4 ± 0.7	15.4 ± 1.1	16.6 ± 0.7	15.6 ± 0.8
Arc						
No insect.	10.0 ± 1.5	11.8 ± 0.3	11.0 ± 1.3	13.8 ± 1.3	10.5 ± 1.3	12.7 ± 1.0
Insecticide	12.1 ± 1.6	13.7 ± 1.1	13.3 ± 1.2	15.0 ± 1.1	12.7 ± 0.6	14.6 ± 1.2
OK08						
No insect.	5.9 ± 0.6	8.8 ± 1.3	8.1 ± 1.3	10.8 ± 1.3	7.5 ± 0.9	9.1 ± 1.1
Insecticide	8.7 ± 1.9	12.2 ± 1.1	8.9 ± 0.9	14.0 ± 1.2	9.2 ± 1.4	11.2 ± 1.5
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	5.0 ± 0.9	10.7 ± 0.9	6.0 ± 0.6	12.2 ± 2.4	3.8 ± 1.0	10.2 ± 1.5
Insecticide	10.4 ± 1.7	12.9 ± 1.3	9.4 ± 1.4	13.6 ± 1.5	11.1 ± 1.5	14.0 ± 0.9
Arc						
No insect.	5.0 ± 1.6	8.0 ± 1.4	4.5 ± 1.4	10.9 ± 2.2	3.3 ± 1.1	6.9 ± 1.9
Insecticide	6.5 ± 1.7	11.9 ± 1.2	8.2 ± 1.4	11.4 ± 1.9	6.5 ± 1.3	13.1 ± 1.2
OK08						
No insect.	0.8 ± 0.5	3.4 ± 1.8	1.2 ± 0.4	4.3 ± 0.9	0.7 ± 0.2	4.1 ± 1.8
Insecticide	2.9 ± 2.0	7.2 ± 2.5	2.6 ± 0.9	8.7 ± 2.4	3.4 ± 1.8	4.9 ± 2.4

TABLE XIII (Continued)

Cultivar	Fall harvested No herb.	Fall harvested Herbicide	Winter grazed No herb.	Winter grazed Herbicide	Unharvested No herb.	Unharvested Herbicide
			Percentage of weeds			
WL318						
No insect.	54.8 ± 4.4	20.7 ± 3.9	54.4 ± 3.4	17.1 ± 9.9	66.9 ± 8.6	24.0 ± 7.6
Insecticide	32.1 ± 7.6	9.8 ± 4.0	39.7 ± 6.5	11.9 ± 4.9	33.4 ± 6.9	10.6 ± 2.4
Arc						
No insect.	53.9 ± 12.4	32.9 ± 10.9	61.8 ± 8.5	21.9 ± 10.2	70.7 ± 8.1	47.1 ± 13.0
Insecticide	48.1 ± 8.4	13.6 ± 4.7	40.3 ± 6.6	25.7 ± 9.3	48.9 ± 9.1	10.0 ± 4.0
OK08						
No insect.	88.1 ± 6.3	67.2 ± 14.4	85.4 ± 4.6	61.0 ± 3.6	90.4 ± 1.5	59.2 ± 14.8
Insecticide	73.5 ± 13.2	43.6 ± 16.0	71.9 ± 8.3	40.4 ± 9.8	67.6 ± 13.0	61.5 ± 14.5

	Total yield	Alfalfa yield	% weeds
LSD for cultivar=	3.1	4.2	20.0
LSD for harvest management=	2.0	2.8	9.1
LSD for pesticide=	0.5	0.6	4.2

TABLE XIV

STUDY TOTAL HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1983-1987, SEASONS 1-5

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Total forage yield (Mg/ha)			
WL318						
No insect.	85.4 ± 2.4	87.4 ± 2.4	86.5 ± 3.3	86.6 ± 1.5	80.2 ± 1.9	80.8 ± 1.6
Insecticide	90.9 ± 0.6	88.6 ± 2.7	88.6 ± 2.0	93.3 ± 0.9	92.7 ± 1.9	89.0 ± 1.3
Arc						
No insect.	87.0 ± 2.3	85.6 ± 3.4	85.9 ± 3.0	89.7 ± 4.4	82.3 ± 4.1	84.3 ± 1.7
Insecticide	90.5 ± 3.0	89.6 ± 3.4	90.3 ± 3.1	89.7 ± 2.3	86.2 ± 4.1	89.3 ± 4.1
OK08						
No insect.	74.3 ± 3.4	74.2 ± 1.5	77.1 ± 4.8	79.4 ± 4.1	70.6 ± 2.0	74.4 ± 3.2
Insecticide	78.5 ± 2.0	84.0 ± 3.7	80.2 ± 3.5	86.3 ± 5.0	80.0 ± 3.2	83.1 ± 3.0
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	72.8 ± 2.3	83.0 ± 2.1	75.2 ± 2.9	83.0 ± 2.8	67.6 ± 2.6	76.9 ± 0.9
Insecticide	83.1 ± 0.7	86.4 ± 3.4	81.0 ± 2.3	90.5 ± 1.6	84.6 ± 2.2	86.5 ± 1.7
Arc						
No insect.	70.2 ± 4.3	79.2 ± 3.6	73.8 ± 3.3	85.1 ± 5.4	66.7 ± 5.1	75.4 ± 3.7
Insecticide	78.9 ± 4.3	85.9 ± 3.1	82.0 ± 2.8	84.8 ± 3.1	75.9 ± 5.3	87.0 ± 4.3
OK08						
No insect.	54.4 ± 4.6	61.5 ± 4.0	58.0 ± 4.9	66.4 ± 4.6	51.8 ± 3.3	65.0 ± 4.7
Insecticide	60.6 ± 5.4	73.5 ± 4.1	65.6 ± 4.2	78.5 ± 5.0	65.6 ± 5.0	69.9 ± 5.2

	Total yield	Alfalfa yield
LSD for cultivar=	6.6	10.2
LSD for harvest management=	7.8	10.2
LSD for pesticide=	1.4	1.6

TABLE XV

STAND PERSISTENCE OF ALFALFA ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1983-1985, SEASONS 1-3[a]

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
9 May 1983						
No insect.	29.7 ± 1.0	31.3 ± 1.1	32.8 ± 0.5	33.2 ± 0.8	31.2 ± 0.8	30.5 ± 0.8
Insecticide	31.9 ± 0.9	29.8 ± 0.9	29.7 ± 0.8	30.8 ± 0.7	29.7 ± 0.7	31.6 ± 1.1
8 May 1984						
No insect.	22.9 ± 0.9	23.4 ± 0.6	25.4 ± 0.5	25.2 ± 1.2	24.2 ± 0.5	24.9 ± 0.8
Insecticide	24.0 ± 0.6	25.0 ± 0.9	25.1 ± 0.8	24.7 ± 0.8	23.5 ± 0.6	24.9 ± 1.0
4 April 1985						
WL318						
No insect.	26.1 ± 2.5	24.1 ± 1.7	25.5 ± 1.4	27.0 ± 0.6	27.0 ± 1.5	26.0 ± 0.5
Insecticide	26.0 ± 0.7	24.7 ± 2.2	24.8 ± 0.9	25.3 ± 1.2	25.7 ± 1.7	26.6 ± 2.3
Arc						
No insect.	22.3 ± 2.3	27.0 ± 1.8	23.9 ± 1.5	24.2 ± 0.6	25.0 ± 1.1	26.7 ± 0.8
Insecticide	24.7 ± 1.4	27.9 ± 2.0	25.6 ± 1.2	27.1 ± 0.9	24.3 ± 0.8	25.3 ± 1.4
OK08						
No insect.	17.8 ± 2.0	21.5 ± 1.0	22.4 ± 2.3	24.3 ± 0.6	23.1 ± 1.4	21.0 ± 1.8
Insecticide	22.0 ± 1.0	21.3 ± 2.0	24.4 ± 2.2	22.6 ± 0.6	20.3 ± 0.9	20.8 ± 2.5

	9 May 1983	8 May 1984	4 April 1985
LSD for cultivar=	4.1	3.3	1.3
LSD for harvest management=	4.1	3.7	1.2
LSD for pesticide=	0.7	0.8	0.9

[a] # of stems/0.1 m^2

TABLE XVI

STAND PERSISTENCE OF ALFALFA ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1986, SEASON 4 [a]

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			15 April			
WL318						
No insect.	15.0 ± 1.3	18.6 ± 1.0	19.2 ± 2.3	21.5 ± 3.3	13.5 ± 1.6	18.0 ± 2.8
Insecticide	20.5 ± 1.3	20.7 ± 1.8	23.6 ± 1.7	24.0 ± 1.1	19.9 ± 0.3	21.6 ± 1.0
Arc						
No insect.	13.6 ± 0.8	17.2 ± 2.4	17.9 ± 0.8	20.1 ± 1.0	13.2 ± 3.4	18.7 ± 1.8
Insecticide	19.4 ± 1.5	20.1 ± 0.8	17.7 ± 1.0	20.5 ± 1.0	16.0 ± 0.9	20.2 ± 1.3
OK08						
No insect.	5.0 ± 2.6	11.4 ± 1.5	6.9 ± 1.4	12.0 ± 2.5	3.8 ± 0.8	12.6 ± 3.5
Insecticide	10.2 ± 2.5	17.1 ± 1.9	15.1 ± 1.9	18.1 ± 1.4	12.7 ± 2.6	13.9 ± 2.6
			2 July			
WL318						
No insect.	16.4 ± 1.4	18.2 ± 1.2	19.5 ± 2.8	15.8 ± 2.2	17.6 ± 0.6	15.6 ± 1.8
Insecticide	18.7 ± 1.3	18.7 ± 1.5	18.3 ± 1.9	18.3 ± 3.2	18.0 ± 1.7	18.0 ± 1.4
Arc						
No insect.	14.1 ± 1.0	11.7 ± 1.8	13.8 ± 1.4	15.3 ± 0.5	14.1 ± 2.5	16.9 ± 1.7
Insecticide	15.4 ± 3.0	15.6 ± 0.6	18.4 ± 0.9	15.2 ± 1.2	15.0 ± 0.6	18.6 ± 1.6
OK08						
No insect.	4.5 ± 1.8	10.0 ± 2.4	7.2 ± 1.8	8.4 ± 1.1	8.8 ± 2.0	11.3 ± 1.5
Insecticide	11.4 ± 1.9	12.9 ± 1.1	12.5 ± 2.8	13.4 ± 2.2	11.2 ± 2.9	10.3 ± 0.8

	15 April 1986	2 July 1986
LSD for cultivar=	5.1	5.1
LSD for harvest management=	4.6	4.4
LSD for pesticide=	1.0	1.0

[a] # of stems/0.1 m^2

TABLE XVII

STAND PERSISTENCE OF ALFALFA ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1987, SEASON 5[a]

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			28 April			
WL318						
No insect.	3.2 ± 1.5	6.1 ± 2.0	6.9 ± 0.9	11.3 ± 3.9	3.7 ± 1.7	8.1 ± 4.3
Insecticide	8.5 ± 2.2	11.2 ± 4.3	11.1 ± 4.4	12.0 ± 4.2	8.5 ± 2.0	11.2 ± 3.1
Arc						
No insect.	5.2 ± 2.0	6.9 ± 1.3	5.2 ± 0.6	8.8 ± 2.4	3.9 ± 1.6	6.7 ± 2.2
Insecticide	5.6 ± 2.5	12.3 ± 1.4	8.8 ± 1.7	10.5 ± 2.6	8.1 ± 2.0	12.5 ± 1.7
OK08						
No insect.	3.3 ± 2.3	5.2 ± 1.7	4.5 ± 2.0	7.8 ± 0.7	1.3 ± 0.6	6.2 ± 1.7
Insecticide	5.6 ± 3.1	7.5 ± 2.5	6.0 ± 2.5	11.3 ± 1.5	9.4 ± 2.2	7.4 ± 3.4
			14 July			
WL318						
No insect.	6.5 ± 1.1	12.5 ± 1.3	10.9 ± 2.4	13.1 ± 1.3	9.1 ± 1.6	14.8 ± 1.2
Insecticide	11.5 ± 0.9	14.4 ± 1.2	13.7 ± 2.5	16.3 ± 1.5	15.6 ± 1.3	15.9 ± 1.0
Arc						
No insect.	6.5 ± 2.3	10.1 ± 1.9	5.7 ± 1.4	12.6 ± 2.3	8.7 ± 2.0	7.9 ± 0.8
Insecticide	8.2 ± 2.3	14.4 ± 2.9	9.2 ± 1.4	12.3 ± 2.8	10.3 ± 0.8	15.1 ± 2.8
OK08						
No insect.	4.8 ± 4.3	4.8 ± 1.5	2.0 ± 0.7	5.1 ± 1.2	2.3 ± 0.7	4.8 ± 2.1
Insecticide	2.8 ± 1.9	7.5 ± 1.4	3.9 ± 1.0	8.2 ± 1.2	5.4 ± 2.1	4.4 ± 2.7

	28 April 1987	14 July 1987
LSD for cultivar=	6.4	4.8
LSD for harvest management=	1.7	3.7
LSD for pesticide=	1.1	0.9

[a] # of stems/0.1 m^2

TABLE XVIII

FINAL ALFALFA PLANT POPULATIONS ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, SEPTEMBER 1987[a]

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
WL318						
No insect.	22.3 ± 6.8	47.3 ± 5.6	30.0 ± 4.1	45.3 ± 5.5	23.0 ± 6.5	36.8 ± 9.9
Insecticide	45.0 ± 4.6	41.8 ± 4.8	40.5 ± 5.2	56.8 ± 5.3	28.3 ± 5.5	50.0 ± 3.9
Arc						
No insect.	26.8 ± 10.2	25.8 ± 3.9	20.5 ± 7.6	50.5 ± 12.3	22.0 ± 4.9	32.8 ± 10.1
Insecticide	29.0 ± 14.0	61.0 ± 9.6	36.5 ± 7.3	38.8 ± 8.9	29.0 ± 8.9	50.3 ± 15.0
OK08						
No insect.	5.5 ± 3.3	18.3 ± 6.7	5.3 ± 2.6	16.5 ± 3.6	6.3 ± 2.7	19.5 ± 4.1
Insecticide	10.5 ± 4.5	24.8 ± 8.7	9.3 ± 1.0	25.3 ± 3.5	20.8 ± 12.5	20.3 ± 9.7

	No./ 0.1 m^2
LSD for cultivar=	21.0
LSD for harvest management=	17.0
LSD for pesticide=	4.1

[a] Number of alfalfa plants per 1 m^2

Chapter IV

LATE FALL HARVEST, WINTER GRAZING AND WEED MANAGEMENT FOR REDUCTION OF ALFALFA WEEVIL POPULATIONS

Adult alfalfa weevils, *Hypera postica* (Gyllenhal), leave summer estivation sites and enter alfalfa fields in October and November in Oklahoma to seek overwintering habitats in fall growth. Areas with abundant plant growth are preferred for overwintering and oviposition by the alfalfa weevil (VanDenburgh et al. 1966, Dively 1970, Dowdy et al. 1986). An abundance of foliage for oviposition in fall may result in greater larval numbers in early spring in regions where viability of eggs remains high throughout winter (Burbutis et al. 1967). Methods for removing this growth and reducing subsequent egg and larval populations are desirable.

Winter grazing of alfalfa by cattle has reduced egg populations by over 60% and also resulted in significantly lower larval populations (Senst & Berberet 1980). However, it has been suggested that grazing by cattle may also reduce stand longevity due to trampling of crowns resulting in plant injury. Late fall harvesting of alfalfa may result in reductions in alfalfa weevil populations similar to those obtained with grazing, but without the potential for damage to plant crowns.

Removal of fall growth with either harvesting or winter grazing opens the crop canopy to allow more light at the soil surface for growth of cool season annual weeds. This may improve the competitive ability of species such as henbit (*Lamium amplexicaule* L.), mustards (*Brassica* spp.), and cheat (*Bromus secalinus* L.). Though alfalfa is dormant during seedling growth of these weeds, it becomes much more competitive after breaking dormancy in late winter. The stand density of alfalfa which effectively limits weed encroachment is not well defined. As stands thin over a period of years, weeds compete more effectively for space and soil moisture and contribute to additional reductions in forage quality (Morrison 1956) and stand density (Berberet et al. 1987, Woodall 1987).

Some weeds, such as henbit, are suitable for oviposition by the alfalfa weevil (Ben Saad & Bishop 1969, Waldrep et al. 1969), which may increase the potential for larval feeding damage. However, Wolfson & Yeargan (1983), Norris et al. (1984), and Lamp et al. (1985) showed that alfalfa weevil larval populations were actually higher in weed-free areas. This indicates that larvae hatching from eggs laid in weeds were perhaps not highly successful in finding suitable feeding locations in alfalfa terminals or that weevil adults tended to avoid weedy stands as sites for oviposition. Berberet et al. (1987) were not able to consistently document increases in alfalfa weevil larval population densities where weeds were controlled versus plots that were heavily infested (predominantly with grasses) suggesting that a weed-specific relationships (broadleaf versus grass) may be present.

The objectives of this chapter were to determine the influence of late fall harvesting and winter grazing in combination with weed control using herbicides on egg deposition and the seasonal occurrence of peak larval populations of the alfalfa weevil.

Materials & Methods

This study was conducted at the South Central Research Station at Chickasha, Oklahoma, on an irrigated alfalfa stand established in the fall of 1981. The experimental design was a split plot in strips configuration with four replications of the alfalfa cultivars 'Arc' (Devine et al. 1975), 'OK08' (Oklahoma common), and 'WL318' (Beard & Kawaguchi 1978) on main plots. Subplots positioned in strips across the main plots were harvest management options consisting of late fall harvest (November) and winter grazing (December and early January) at a stocking rate of 12-15 cattle/ha for a 2-3 wk period. The third subplot was left uncut and ungrazed during fall and winter to determine the potential for egg and larval populations where fall growth remained. The final harvest of the season on these plots was taken in mid-September after which plants produced 20-25 cm of fall growth.

Carbofuran insecticide and the herbicides terbacil and oryzalin were applied annually in a 2 x 2 factorial design on sub-subplots within each cultivar by harvest management combination. The resulting treatment combinations included 1) insecticide only to control weevils but allow weed infestation, 2) the herbicides only to control weeds but allow alfalfa weevil infestation, 3) both insecticide and herbicides to create a "pest-free" treatment, and 4) unsprayed plots to allow infestation of both weevils and weeds. Naturally occurring insect and weed populations were utilized until the summer of 1985 when seed of B. secalinus was broadcast @ 15 kg/ha to increase the potential for weed competition during winter and spring of 1986 and 1987. Harvest and pesticide treatments were first imposed in the fall of 1982 and spring of 1983, respectively.

Stem density determinations (stems/0.1 m^2) were made prior to first harvest each spring to estimate effects of harvest management treatments and pest infestations on stand persistence. Stem densities were also measured at the time of the late fall cut in 1985 and 1986 (seasons 4 and 5) to measure differences which had become evident in stem densities of some treatment combinations and to determine overwintering habitat available to adult weevils.

Egg populations were sampled during each winter at 1) pregrazing (December) to determine populations of fall laid eggs, 2) postgrazing (January) to document the affects of winter grazing on egg numbers, and 3) at the initiation of spring growth of alfalfa (February or March) prior to the greatest period of larval hatch. Four 0.025 m^2 samples of foliage were taken from each subplot and eggs were separated from the plant material utilizing the blender extraction method of Pass & VanMeter (1966) and reported here in numbers/0.1 m^2. The lengths (cm) of 25 stems per subplot were measured after the postgrazing egg samples to compare habitat available for oviposition by overwintering adult weevils in grazed, harvested, and unharvested treatments.

By the fall of 1986, the effects of varied pest infestation levels had resulted in a wide variety of stem densities and weed infestations that could potentially influence habitat selection of adult alfalfa weevils. To determine if the presence or absence of weeds effected the choice of habitat by adult weevils, the sampling procedure was modified to allow comparison among sub-subplots that had been treated with herbicides and those that had not. Broadleaf and grassy weed populations were recorded during late fall and mid-winter of 1986-1987 (season 5) so comparisons of adult weevil habitat preference could be made among herbicide-treated and untreated sub-subplots as indicated by egg deposition.

Larval populations were sampled based upon Celsius day degree (CDD) accumulations utilizing a developmental threshold of 10°C (Hsieh et al. 1974). The historical peak larval population occurs at about 280 CDD from 1 January for the Chickasha area (Berberet unpublished data). Samples were obtained at approximately 220, 280, and 340 CDD in an effort to obtain the best estimates of peak larval populations and detect any differences due to management practices. A 25-stem sample was taken from each sub-subplot and larvae were extracted using Berlese funnels. From these samples, the numbers of larvae per stem were calculated. The numbers of larvae/0.1 m^2 were determined by multiplying the numbers per stem by the stem density/0.1 m^2.

Weed infestation may be a factor influencing larval numbers and survival, therefore, visual estimates of the percentage of weeds in the forage were made at first harvest. Accuracy of estimates was checked periodically by comparison of results with clipping 0.5 m^2 quadrats followed by plant separations and weighing of weed and alfalfa components.

All data were subjected to the analysis of variance procedure and F-tests were utilized to detect significant interactions among treatment components (SAS 1985). Mean separations were accomplished with least significant difference tests at the 0.05 level of probability (Steel & Torrie 1980). All data are presented by subplot or sub-subplot to facilitate communication of the effects of treatment levels over years. Therefore, calculated F values obtained through analyses of the data in a split-plot in strips configuration are not necessarily descriptive of the means presented. All F values and associated degrees of freedom are presented in Appendix B.

Results

1982-83 (Season 1)

All harvest management subplots were harvested on 20 September 1982. Late fall harvests were made on 16 November to remove fall growth and minimize overwintering habitat for adult weevils. Winter grazing began 15 December and continued until 24 December.

Numbers of eggs deposited by weevil adults in fall of 1982 were lower than at any other time during the study. Pregrazing counts of alfalfa weevil eggs were considerably lower in Arc than the other cultivars when sampled prior to grazing (Table I - 14 December). Significantly fewer eggs were present in fall harvested compared to unharvested subplots of WL318.

The first hard freeze that killed fall growth in 1982 occurred 15 November (-7°C) and plant heights of this growth measured in January in subplots left unharvested through winter averaged 17-20 cm. This growth had been removed except for short stubble in the fall harvested and grazed treatments. New growth from crowns was present in all subplots through the winter and measured 3.5-4.2 cm in January in the fall harvested and winter grazed treatments. After grazing (8 January 1983) there were no significant differences among cultivars in abundance of alfalfa weevil eggs/0.1 m^2 (Table I). Winter grazing resulted in significantly lower egg populations than the unharvested treatment only in WL318. Fall harvested subplots also continued to have fewer eggs/0.1 m^2 than unharvested alfalfa in WL318.

Alfalfa weevil egg populations sampled as growth of the alfalfa plants accelerated in late winter (25 February) were not significantly different among cultivars (Table I). Subplots harvested in late fall or grazed in winter had significantly fewer eggs/0.1 m^2 than the unharvested subplots in all cultivars. Egg populations had increased from the previous sampling dates indicating that most oviposition occurred during late winter or early spring.

Peak alfalfa weevil larval populations in 1983 averaged 0.1 per stem in sub-subplots that had been treated with insecticide. Means ranged from 2.2 to 4.0 per stem in those that had not been treated and exceeded the economic threshold of 1.5-2.0 larvae per stem (Table II). The cultivars WL318 and OK08 typically had more larvae than were present in Arc. Significantly more larvae per stem were present in unharvested plots than in those harvested in late fall in subplots of Arc treated with herbicides. The only significant difference in absolute density of larvae among harvest management treatments occurred in OK08 alfalfa with significantly more larvae/0.1 m^2 present in winter grazed subplots than unharvested or fall harvested subplots, respectively. Less than 4% weeds were present in the forage of the first cutting in sub-subplots that had not been sprayed with herbicides and were not detectable in the forage from sub-subplots treated with herbicides. There was no consistent difference in larval populations among sub-subplots treated and not treated with herbicides (Table II). Alfalfa stem density averaged 31 stems/0.1 m^2 and offered similar weevil habitat in all treatment combinations.

Most alfalfa weevil egg deposition occurred in late winter and spring. Although the subplots left unharvested through winter averaged ca. 14-38 more eggs/0.1 m^2 on 25 February, the benefits of late fall harvesting or winter grazing were not as evident as would be expected had egg deposition been greater during fall and early winter. As a result of the seasonal pattern for egg deposition, the occurrence of peak larval density was ca. 4 May (311 CDD) in 1983 was the same for all harvest management treatments.

1983-84 (Season 2)

When sampled prior to grazing on 8 December 1983, alfalfa weevil egg numbers in subplots due to be grazed were significantly lower in Arc and OK08 than in WL318 (Table III). There were no observable differences in fall growth that may have accounted for this. Fall harvesting had resulted in significantly fewer eggs/0.1 m^2 than in the other harvest management treatments. In contrast to the egg deposition pattern of 1982-83, large numbers of eggs were laid in late fall and early winter.

Fall growth was killed by frost 29 November in 1983 (-5°C) and plant heights measured in January of 1984 in subplots left unharvested through winter averaged about 41 cm while the short green growth about plant crowns averaged 7.1-9.4 cm in all harvest management treatments. When eggs were sampled after grazing (11 January 1984) there were no significant differences among alfalfa cultivars so what ever factor may have caused previous differences among cultivars in the winter grazed subplots was no longer evident (Table III). Additionally, there appeared to have been very little egg deposition since December. Grazing of alfalfa resulted not only in the removal of fall growth and overwintering habitat for adult weevils but destruction of many eggs. Egg population densities in fall harvested subplots continued at about one-third the level of those in unharvested alfalfa.

Alfalfa weevil egg populations sampled as growth accelerated in late winter (9 March) were lower than on 11 January but were not significantly different among cultivars (Table III). The number of alfalfa weevil eggs/0.1 m^2 continued to be much lower due to harvesting in late fall or grazing in winter than not harvesting through winter.

High egg populations through the winter indicated that larval numbers would also be high. However, the percentage of viable eggs was less than 40% in the 11 January and 9 March samples due to daily low temperatures below -13°C for more than a week during December. This resulted in lower larval numbers than may have been predicted based on egg populations.

Peak alfalfa weevil larval populations in virtually all treatment combinations were below economic threshold levels (Table IV). The occurrence of peak larval densities was approximately 14 April (507 CDD) with no difference among treatment combinations. The numbers of weevil larvae per stem at peak density were not significantly different among cultivars or harvest management treatments (Table IV). Weed infestations were minimal in all treatment combinations as evidenced by less than 5% of the forage at first harvest was comprised of weeds. No consistent difference in the number of larvae per stem occurred among herbicide treatments indicating that weed infestations were not great enough to affect habitat selection and oviposition by adult weevils.

Although peak larval populations did not differ significantly among harvest management treatments when considered on a per stem basis, winter grazed subplots had about half as many larvae per stem as the unharvested treatment which resulted in significantly fewer larvae/0.1 m^2 in subplots that had been grazed (Table IV) even though both treatments had mean stem densities of ca. 24.0/0.1 m^2. In unharvested alfalfa, 3.6-7.2 more larvae/0.1 m^2 were present in sub-subplots where weeds had been controlled than in the unsprayed treatment.

1984-85 (Season 3)

As in 1983-84 (season 2), most alfalfa weevil eggs were laid during the late fall and early winter with populations declining after January. When sampled on 4 January 1985, there were no apparent differences in habitat to cause significantly lower egg numbers in Arc prior to grazing relative to this treatment in WL318 and OK08 (Table V). This happened previously in the pregrazing egg sample of 8 December 1983. No significant differences among cultivars were present in the other harvest management treatments. Fall harvesting resulted in significant reductions in egg numbers in all cultivars.

Fall growth was killed by freezing temperatures on 2 December 1984 (-6°C) and when measured in January, plant height of this growth was about 23 cm in unharvested subplots while all harvest treatments had green growth of about 3 cm about plant crowns. There appeared to have been no appreciable oviposition after early January. After grazing (14 February), fall harvested and winter grazed subplots had significantly fewer eggs/0.1 m^2 than the unharvested subplots in all cultivars (Table V).

By 8 March, many weevil eggs were hatching and numbers in all treatments were lower than on 14 February. Populations of eggs/0.1 m^2 were significantly greater in WL318 than in the other cultivars when left unharvested (Table V). Fall harvested and winter grazed alfalfa continued to have significantly fewer eggs than that left unharvested in all cultivars.

On 3 April 1985, the entire research area was accidentally oversprayed with methyl parathion by an aerial applicator prior to collection of the first larval samples.

Applications of carbofuran insecticide had been made previously to appropriate sub-subplots to establish differences in larval infestations. No larval numbers are available and damage ratings taken after the overspray ranged from 4 to 5 (1= no damage, 9= complete defoliation) in sub-subplots that had not been sprayed earlier with carbofuran. Larval populations monitored in a nearby unsprayed population study 8 days prior to the overtreatment indicated that third and fourth instar larval populations were quickly approaching the economic threshold of 1.5-2.0 per stem and would likely have exceeded this level before the methyl parathion was applied. Egg populations indicated that peak larval density would have been comparable to populations that were later recorded in 1987.

1985-86 (Season 4)

Stem density measurements on 5 November 1985 averaged ca. 18 stems/0.1 m^2 in all harvest management treatments. Arc averaged ca. 17 stems/0.1 m^2 while OK08 averaged ca. 16 stems, significantly less than WL318 with ca. 22/0.1 m^2. A comparable egg deposition pattern occurred in this season as in 1983-84 and 1984-85 (seasons 2 and 3) with most eggs being laid in late fall and early winter. Prior to grazing on 17 December, there were no significant differences among alfalfa cultivars in the abundance of alfalfa weevil eggs/0.1 m^2 (Table VI). Subplots harvested in late fall had significantly fewer eggs than the other harvest management treatments.

Height of fall growth that had been killed by a hard freeze on 1 December 1985 (-10°C) averaged 38 cm in subplots left unharvested. All treatments contained green growth about plant crowns of 2.0-2.3 cm. Postgrazing egg populations recorded 2 January 1986 were significantly greater in the unharvested subplots than in those that had been grazed in Arc and OK08 and the fall harvested treatment in OK08 (Table VI). There were no significant differences in egg numbers among alfalfa cultivars.

On 25 February, egg numbers were much lower than on 12 January due to hatching. Numbers were significantly higher in grazed subplots of WL318 than in OK08 (Table VII). Unharvested subplots had significantly higher egg populations than the winter grazed subplots in Arc and OK08 and the fall harvested subplots in Arc.

The highest egg populations of the study were recorded during this year and the greatest peak larval density was also anticipated. The percentage of viable eggs through winter averaged ca. 80%. The numbers of alfalfa weevil larvae per stem at peak population densities were not significantly different in sub-subplots treated with insecticide and all were below the economic threshold. Those sub-subplots not treated with insecticide had peak larval populations of 3.4-8.0 per stem but were not consistently different among cultivars (Table VII). The number of alfalfa stems averaged 15-16/0.1 m^2 in the cultivars WL318 and Arc whereas numbers in OK08 were ca. 5/0.1 m^2 which contributed to lower absolute density of weevil larvae in OK08 but not per stem density. Weevil larval numbers per stem were significantly lower in winter grazed sub-subplots of Arc and OK08 than those left unharvested through the winter. However, larval numbers/0.1 m^2 were generally not significantly different among harvest management treatments. Although some significant differences occurred in larval numbers per stem in herbicide treated versus untreated sub-subplots, only in the fall harvested treatment was there a clear trend favoring weed infestation for increasing the number of larvae per stem (Table VII). However, the numbers of larvae/0.1 m^2 tended to be significantly greater in sub-subplots that were treated with herbicides than in the unsprayed treatment (Table VII). Stem densities of these sub-subplots averaged 18/0.1 m^2, 2.5-3.0 stems more than sub-subplots not treated with herbicides. The percentage of weedy material in the forage of first harvest in 1986 averaged about 60% in unsprayed sub-subplots and 10% where weeds had been controlled. In 1986 (season 4), the occurrence of peak larval populations was about 12 March (193 CDD) in subplots harvested in late fall or left unharvested through winter. Peak density in winter grazed subplots occurred about 10 days later (238 CDD) allowing additional plant growth.

1986-87 (Season 5)

By the fall of 1986, the effects of insect and weed infestations had resulted in highly variable compositions of alfalfa and weeds in sub-subplots that could potentially influence habitat selection by adult alfalfa weevils. To determine possible effects of weed infestation on habitat selection and subsequent egg deposition by adult weevils, sampling procedures were modified to allow comparison of egg numbers among sub-subplots that had and had not been treated with herbicides.

The stem densities in WL318 and Arc averaged 12 and 10/0.1 m^2, respectively, while OK08 had fewer than 6. This raised the possibility of OK08 being less attractive to adults. Winter broadleaf and grass weed populations were counted in WL318 and Arc on 18 November. Weed counts demonstrated that both herbicide treated and untreated sub-subplots contained about 20 grass plants/0.1 m^2 while broadleaf weeds averaged 11/0.1 m^2 in treated sub-subplots and 28/0.1 m^2 in those not sprayed for weeds. Many OK08 plots had become so infested with bermudagrass that a dense sod had formed making counts of individual weed plants impossible. When alfalfa stands had declined to low levels, the herbicides had become less effective in controlling weed encroachment.

Alfalfa weevil egg deposition was similar to 1982-83 (season 1) with more eggs/0.1 m^2 estimated from the late winter samples than from the pre- or postgrazing samples in unharvested subplots particularly. Egg populations sampled prior to grazing (2 December) were, in most harvest and herbicide combinations, significantly greater in WL318 than the other cultivars (Table VIII). In WL318, fall harvesting resulted in lower egg numbers than were present in either the unharvested treatment or the sub-subplots that had been grazed the last four winters. Weevil eggs were significantly more abundant in sub-subplots where weeds had been controlled with herbicides, and alfalfa stem density averaged 9.7/0.1 m^2, than in sub-subplots where weed infestations had not been suppressed and averaged 6.6 stems/0.1 m^2.

Fall growth was killed by frost on 11 November 1986 (-6°C) and plant height of fall growth was ca. 34 cm in unharvested subplots. WL318 continued with significantly more weevil eggs than the other cultivars in fall harvested and unharvested treatments (Table VIII). Grazing of fall growth generally resulted in significantly reduced egg populations to levels below those of the fall harvested and unharvested treatments. Because more alfalfa plant material was present in sub-subplots that had been treated with herbicides than those left unsprayed there were typically significantly more weevil eggs/0.1 m^2, except in winter grazed subplots and WL318 that had been harvested in fall (Table VIII).

The populations of weeds decreased through winter and grass plants numbered about 19/0.1 m^2 when counted 10

February 1987. Broadleaf weeds averaged 8/0.1 m^2 in herbicide treated and 15/0.1 m^2 in untreated sub-subplots.

On 19 February, WL318 continued to possess significantly more weevil eggs/0.1 m^2 than Arc and OK08 in most harvest and herbicide treatment combinations. In general, numbers of eggs had increased greatly in the interval since grazing had ceased. A corresponding increase in egg numbers had occurred in fall harvested sub-subplots that had received herbicides (Table VIII). Weevil eggs continued to be significantly less abundant in the winter grazed than the unharvested plots in WL318 and Arc.

Peak alfalfa weevil larval populations averaged 0.8-2.6 in insecticide treated sub-subplots but persisted for only a short time at the higher numbers and did little detectable damage. No significant differences in peak larval numbers resulted among cultivars or harvest management treatments when treated with insecticide. Larval numbers per stem were generally significantly higher in WL318 than OK08 (Table IX). However, the numbers of larvae/0.1 m^2 was generally not significantly different. Stem densities of alfalfa averaged ca. 7.6/0.1 m^2 in spring in all cultivars but weeds composed 40-45% of the first harvest forage of WL318 and Arc while about 64% of the forage from OK08 was weedy material. Lower stem density in OK08 in fall offered fewer ovipositional locations for adult weevils resulting in lower egg numbers through the winter and larval populations that typically remained significantly lower than the other cultivars.

Significantly lower numbers of larvae per stem usually occurred in the winter grazed subplots than in either of the subplots harvested in late fall or left unharvested through winter (Table IX). However, the number of larvae/0.1 m^2 was generally not different among harvest management treatments.

Herbicide treated sub-subplots in unharvested alfalfa generally had significantly more larvae/0.1 m^2 than sub-subplots without herbicides (Table IX). Sub-subplots treated with herbicides contained about 29% weeds at first harvest versus 70% weeds in sub-subplots where weeds were not managed. Stem densities were similar to densities measured the previous fall in all treatment combinations. Peak larval populations occurred ca. 28 March in 1987 (160 CDD) in all treatments.

Discussion

Alfalfa weevil egg populations and the occurrence of peak larval density differed substantially from year to year due to differences in weather conditions that affected egg deposition and hatching. Alfalfa weevil egg populations were not consistently different among alfalfa cultivars until 1987 when lower stem densities in Arc and OK08 resulted in less overwintering habitat for adult weevils and lower egg numbers than were present in WL318.

Late fall harvesting of alfalfa reduced the overwintering habitat for adult alfalfa weevils and I hypothesize that this resulted in fewer adults in these subplots. Additionally, this resulted in the accumulation of about half as many eggs/0.1 m^2 during late fall and winter relative to unharvested alfalfa. Compared to alfalfa left unharvested through winter, weevil eggs were less numerous in the fall harvested and winter grazed subplots due to removal of the fall growth and any eggs laid therein. Dively (1970) and Dowdy et al. (1986) demonstrated that the principal determining factor for oviposition preference by adult weevils appears to be the amount of alfalfa foliage available for overwintering. Fall harvesting or winter grazing reduces this habitat and results in a less suitable environment for overwintering adults. Also, by removing fall growth and the weevil eggs laid therein, there is potential for reduction of larval feeding damage in spring (Burbutis et al. 1967).

Grazed sub-subplots that had been treated with herbicides had somewhat lower egg populations than those not sprayed. Sub-subplots treated with herbicides and harvested in late fall or left unharvested through the winter had many more eggs in 1987 (season 5) than those not sprayed even though significant differences did not always occur. Contrary to my findings, Ben Saad & Bishop (1969) and Wolfson & Yeargan (1983) showed greater alfalfa weevil egg populations in plots with high weed densities. Wolfson & Yeargan (1983) reported that this occurred with similar alfalfa stem densities in plots infested at low and high weed densities. Ben Saad & Bishop (1969) and Waldrep et al. (1969) recorded more feeding damage may be expected when the predominant weed is suitable for oviposition by the weevil. The predominant weed in my study was cheat which has not been shown to be suitable for oviposition by the alfalfa weevil.

Reduction in egg populations due to fall harvesting or winter grazing did not necessarily result in lower larval numbers. This may be due to establishment mortality of first instar larvae in unharvested subplots as they moved from oviposition sites in frost killed fall growth to feeding sites in terminals of green stems. Just as weeds are not suitable feeding sites for weevil larvae (Ben Saad & Bishop 1969), it is probable that dead alfalfa stems are also unsuitable. Peak alfalfa weevil larval populations were not substantially reduced by fall harvesting relative to unharvested alfalfa. Failure to produce large reductions in larvae was also typical for winter grazing in 1983 and 1984 (seasons 1 and 2), but in the last 2 years of the study, grazing reduced larval abundance by 1.0-2.0 larvae per stem relative to alfalfa left unharvested through winter. When larval populations were analyzed based on absolute densities, grazing resulted in 13-27 fewer larvae/0.1 m^2 relative to unharvested subplots in 1984. In 1986, grazing of herbicide treated sub-subplots resulted in 12-41 fewer larvae/0.1 m^2 than unharvested subplots. In sub-subplots not treated with herbicides, grazing reduced peak larval populations by nearly 50/0.1 m^2 in Arc. However, larval numbers were about 15/0.1 m^2 higher after grazing in WL318 and OK08 treated with herbicides relative to the unharvested treatment even though stem densities and weed infestations were similar in Arc and WL318 indicating that similar habitats existed. There was a general tendency for peak occurrence to be delayed due to winter grazing. For instance, peak larval density was significantly delayed by winter grazing in 1986 by ca. 10 days relative to peak occurrence in alfalfa left unharvested through winter.

Woodall (1987) reported that weeds were not successfully controlled after alfalfa stem density dropped below ca. 20/0.1 m^2. These stem densities occurred in my study by the spring of 1986 but not until 1987 were there sufficient weed infestations in the unsprayed sub-subplots to document consistently lower alfalfa weevil larval populations. The numbers of larvae were ca. 0.7 per stem and nearly 30/0.1 m^2 less in the unsprayed sub-subplots than in those which received the herbicides. This indicates that not only was the number of larvae/0.1 m^2 greater where herbicides were used due predominantly to higher alfalfa stem densities, but the number of larvae per unit of habitat (per stem) was increased as well. Wolfson & Yeargan (1983) and Norris et al. (1984) also showed an increase in the relative density of alfalfa weevil larvae when weed biomass was reduced. Berberet et al. (1987) found that increased populations of grasses due to thinning of alfalfa stands resulted in a lower numbers of weevil larvae per stem. These authors findings agree with the "resource concentration hypothesis" of Root (1973) that states a herbivore is more likely to be in higher relative density in a purer stand of suitable host plants than in an environment with abundant non-host material.

In conclusion, alfalfa weevil egg populations were substantially reduced by late fall harvesting or grazing. However, peak larval numbers were typically not reduced possibly due to mortality of first instar larvae from eggs laid in frost killed fall growth that had to move to feeding sites in terminals of green stems. There appeared to be potential to delay the occurrence of peak density by harvesting in late fall or winter grazing in years when the majority of weevil eggs were laid in fall or early winter and viability remained high. By delaying the occurrence of peak larval populations, a producer may be able to reduce the rate of insecticide necessary or the number of applications required to manage the alfalfa weevil below the economic threshold of 1.5-2.0 larvae per stem.

Control of weeds with herbicides throughout the study did result in an increased larval abundance compared to unsprayed sub-subplots. Though treatment with herbicides did not successfully control weeds after alfalfa stem density dropped below ca. 20/0.1 m^2, it did result in a somewhat greater stem density than the unsprayed treatment, leaving potential for a larger absolute density of weevil larvae.

References cited

Beard, D. F., & I. I. Kawaguchi. 1978. Registration of WL311 and WL318 alfalfa cultivars. (Reg. Nos. 85 86). Crop Sci. 18: 523.

Ben Saad, A. A., & G. W. Bishop 1969. Egg-laying by the alfalfa weevil in weeds. J. Econ. Entomol. 62: 1226-1227.

Berberet, R. C., J. F. Stritzke, & A. K. Dowdy. 1987. Interactions of alfalfa weevil (Coleoptera: Curculionidae) and weeds in reducing yield and stand of alfalfa. J. Econ. Entomol. 80: 1306-1313.

Burbutis, P. P., D. F. Bray, & A. H. Mason. 1967. Overwintering eggs of the alfalfa weevil in Delaware. J. Econ. Entomol. 60: 1007-1010.

Devine, T. E., R. H. Ratcliffe, C. M. Rinker, D. K. Barnes, S. A. Ostazeski, T. H. Busbice, C. H. Hanson, J. A. Schillinger, G. R. Buss, & R. W. Cleveland. 1975. Registration of Arc alfalfa. (Reg. No. 76). Crop Sci. 15: 97.

Dively, G. P., Jr. 1970. Overwintering alfalfa weevil eggs in three stages of alfalfa growth in New Jersey. Ann. Entomol. Soc. Amer. 63: 1213-1216.

Dowdy, A. K., R. C. Berberet, & J. L. Caddel. 1986. Population densities of alfalfa weevil, Hypera postica ((Coleoptera: Curculionidae), with varied fall planting dates for alfalfa. J. Econ. Entomol. 79: 790-796.

Hsieh, T. R., S. J. Roberts, & E. J. Armbrust. 1974. Developmental rate and population dynamics of alfalfa weevil larvae. Environ. Entomol. 3: 593-597.

Lamp, W. O., K. V. Yeargan, R. F. Norris, C. G. Summers & D. G. Gilchrist. 1985. Multiple pest interactions in alfalfa. In Integrated Pest Management on Major Agricultural Systems. R. E. Frisbie & P. L. Adkisson, eds. Texas Agr. Exp. Stn. MP-1616.

Morrison, F. B. Feeds and Feeding. Ed. 22, 1165p. illus. Ithica, New York. 1956.

Norris, R. F., W. R. Cothran, & V. E. Burton. 1984. Interactions between winter annual weeds and Egyptian alfalfa weevil in Alfalfa. J. Econ. Entomol. 77: 43-52.

Pass, B. C., & C. L. VanMeter. 1966. A method for extracting eggs of the alfalfa weevil from stems of alfalfa. J. Econ. Entomol. 59: 1294.

Root, R. B. 1973. Organization of a plant-arthropod association in simple and diverse habitats: the fauna of collards (Brassica oleracea). Ecological Monographs 43: 95-124.

SAS Users guide: statistics, version 5 edition. 1985. SAS Institute, Cary, North Carolina. 957p.

Senst, K. M., & R. C. Berberet. 1980. Effects of winter grazing of dormant alfalfa stands on populations of Hypera postica (Gyllenhal) and its parasite Bathyplectes curculionis (Thomson). J. Kansas Entomol. Soc. 53: 230-234.

Steel, R. G. D. & J. H. Torrie. 1980. Principles and Procedures of Statistics: a Biometric Approach. 2nd Ed. McGraw-Hill Book Co., Inc.

VanDenburgh, R. S., B. L. Norwood, C. C. Blickenstaff, & C. H. Hanson. 1966. Factors affecting resistance of alfalfa clones to adult feeding and oviposition of the alfalfa weevil in the laboratory. J. Econ. Entomol. 59: 1193-1198.

Waldrep, T. W., D. S. Chamblee, D. Daniel, W. A. Cope, & T. H. Busbice. 1969. Damage to alfalfa by the alfalfa weevil as related to infestation by henbit. Crop Sci. 9: 388.

Wolfson, J. L. & K. V. Yeargan. 1983. The effects of metribuzin on larval populations of alfalfa weevil, Hypera postica (Coleoptera: Curculionidae). J. Kansas Entomol. Soc. 56: 40-46.

Woodall, T. K. 1987. Effects of fall forage removal and pesticide treatments on weeds in alfalfa. M.S. thesis, Oklahoma State Univ., Stillwater.

TABLE I

H. POSTICA EGGS/0.1 m^2 ($\bar{x} \pm SE$) AS INFLUENCED BY HARVEST MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1982-83

Cultivar	Fall harvested	Winter grazed	Unharvested
	14 December 1982		
WL318	1.5 ± 0.8	5.8 ± 1.5	6.8 ± 2.2
Arc	3.3 ± 1.4	1.6 ± 0.8	3.7 ± 1.1
OK08	3.5 ± 1.0	8.6 ± 3.3	4.9 ± 1.0
	8 January 1983		
WL318	5.9 ± 1.4	7.3 ± 1.8	15.4 ± 3.2
Arc	6.3 ± 1.4	6.2 ± 1.6	11.6 ± 2.2
OK08	11.8 ± 2.7	7.4 ± 1.5	11.9 ± 2.8
	25 February 1983		
WL318	33.3 ± 7.0	19.5 ± 5.6	57.5 ± 9.5
Arc	21.9 ± 4.1	19.9 ± 2.7	56.6 ± 9.8
OK08	23.6 ± 3.4	13.8 ± 2.9	40.6 ± 6.4

	14 Dec.	8 Jan.	25 Feb.
L.S.D. for cultivar=	4.5	6.1	19.0
L.S.D. for harvest management=	4.7	6.0	16.7

TABLE II

PEAK *H. POSTICA* LARVAL NUMBERS ($\bar{x}$ ± SE) AS INFLUENCED BY HARVEST AND HERBICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1983

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
WL318						
#/stem	3.1 ± 0.7	3.8 ± 0.3	3.6 ± 1.0	3.1 ± 0.4	2.8 ± 1.0	3.9 ± 0.3
#/0.1 m^2	94.3 ±21.8	124.0 ±13.0	113.9 ±33.7	101.3 ±14.2	85.3 ±31.1	116.9 ±11.7
Arc						
#/stem	2.6 ± 0.5	2.2 ± 0.2	2.5 ± 0.3	2.4 ± 0.2	2.6 ± 0.4	3.4 ± 0.5
#/0.1 m^2	73.0 ±12.0	73.9 ± 5.3	84.6 ± 9.4	81.9 ± 6.2	85.6 ±13.4	101.4 ±15.9
OK08						
#/stem	3.0 ± 0.3	3.3 ± 0.6	3.3 ± 0.4	3.9 ± 0.5	4.0 ± 0.5	3.0 ± 0.2
#/0.1 m^2	88.5 ± 9.9	89.8 ±10.6	110.9 ±12.6	127.7 ±15.8	113.9 ± 8.1	94.3 ± 4.8

	#/stem	#/0.1 m^2
L.S.D. for cultivar=	1.0	31.0
L.S.D. for harvest management=	1.0	32.1
L.S.D. for herbicides=	0.2	7.1

Table contains means for sub-subplots that received no carbofuran treatment.

TABLE III

H. POSTICA EGGS/0.1 m^2 ($\bar{x}$ ± SE) AS INFLUENCED BY HARVEST MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1983-84

Cultivar	Fall harvested	Winter grazed	Unharvested
	8 December 1983		
WL318	43.7 ±11.8	118.3 ± 16.3	113.2 ±15.8
Arc	23.3 ± 3.2	80.4 ± 12.3	93.1 ±17.0
OK08	22.4 ± 5.7	76.8 ± 16.3	114.0 ±11.5
	11 January 1984		
WL318	34.6 ±11.8	19.1 ± 3.5	95.4 ±18.4
Arc	36.3 ± 7.3	33.0 ± 6.2	90.8 ±16.1
OK08	37.4 ± 6.1	29.4 ± 6.5	92.8 ±15.2
	9 March 1984		
WL318	17.8 ± 3.6	5.8 ± 1.4	43.9 ± 8.0
Arc	10.8 ± 2.7	5.1 ± 1.5	46.1 ± 8.7
OK08	9.3 ± 1.5	16.8 ± 6.1	47.6 ± 6.2

	8 Dec.	11 Jan.	9 Mar.
L.S.D. for cultivar=	35.1	32.5	12.6
L.S.D. for harvest management=	36.2	31.5	15.3

TABLE IV

PEAK *H. POSTICA* LARVAL NUMBERS ($\bar{x}$ ± SE) AS INFLUENCED BY HARVEST AND HERBICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1984

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
WL318						
#/stem	0.9 ± 0.1	0.8 ± 0.1	0.5 ± 0.1	0.5 ± 0.1	1.1 ± 0.2	1.3 ± 0.1
#/0.1 m^2	21.4 ± 3.7	20.3 ± 3.2	12.4 ± 1.3	14.5 ± 2.3	27.5 ± 4.5	32.7 ± 7.4
Arc						
#/stem	1.0 ± 0.1	0.9 ± 0.1	0.4 ± 0.1	0.5 ± 0.1	1.0 ± 0.2	1.2 ± 0.1
#/0.1 m^2	24.9 ± 3.1	21.3 ± 7.5	10.4 ± 1.4	14.0 ± 2.2	23.7 ± 5.0	27.3 ± 3.1
OK08						
#/stem	1.2 ± 0.3	1.0 ± 0.2	0.8 ± 0.3	0.8 ± 0.1	1.5 ± 0.5	1.7 ± 0.4
#/0.1 m^2	25.7 ± 8.3	22.1 ± 2.7	18.5 ± 6.5	16.4 ± 2.4	36.7 ±14.4	43.9 ±12.9

	#/stem	#/0.1 m^2
L.S.D. for cultivar=	3.1	11.1
L.S.D. for harvest management=	3.1	11.0
L.S.D. for herbicides=	0.1	2.4

Table contains means for sub-subplots that received no carbofuran treatment.

TABLE V

H. postica EGGS/0.1 m^2 ($\bar{x} \pm$ SE) AS INFLUENCED BY HARVEST MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1984-85

Cultivar	Fall harvested	Winter grazed	Unharvested
	4 January 1985		
WL318	52.9 ± 6.8	167.9 ± 15.9	130.3 ±15.5
Arc	66.2 ±10.9	119.6 ± 17.4	137.7 ±23.4
OK08	64.0 ±17.8	154.0 ± 14.0	124.5 ±12.0
	14 February 1985		
WL318	42.4 ± 5.7	51.8 ± 9.7	128.5 ±13.9
Arc	48.5 ± 9.1	45.9 ± 8.3	103.3 ±14.0
OK08	51.9 ± 6.4	58.2 ± 10.5	115.6 ±15.8
	8 March 1985		
WL318	38.1 ± 5.2	37.5 ± 5.9	79.4 ± 9.2
Arc	22.1 ± 3.5	33.4 ± 6.6	61.0 ± 6.1
OK08	27.6 ± 4.8	33.7 ± 3.2	61.3 ± 7.2

	4 Jan.	14 Feb.	8 Mar.
L.S.D. for cultivar=	46.8	30.3	17.0
L.S.D. for harvest management=	41.3	30.3	16.4

TABLE VI

<u>H.</u> <u>POSTICA</u> EGGS 0.1 m^2 ($\bar{x} \pm$ SE) AS INFLUENCED BY HARVEST MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1985-86

Cultivar	Fall harvested	Winter grazed	Unharvested
	17 December 1985		
WL318	106.1 ±10.9	259.2 ± 18.7	224.8 ±25.3
Arc	75.4 ± 9.8	229.9 ± 27.3	240.1 ±29.4
OK08	102.6 ±16.7	234.4 ± 30.5	236.4 ±24.8
	2 January 1986		
WL318	114.1 ±18.8	65.8 ± 8.9	245.9 ±29.9
Arc	114.8 ±11.7	67.9 ± 9.5	218.0 ±21.5
OK08	88.9 ±11.3	56.6 ± 9.5	242.4 ±33.3
	25 February 1986		
WL318	54.2 ± 9.2	63.3 ± 12.1	72.6 ±11.2
Arc	31.1 ± 4.6	43.8 ± 5.3	81.8 ±11.2
OK08	51.8 ± 9.4	24.7 ± 6.2	58.4 ± 8.3

	17 Dec.	2 Jan.	25 Feb.
L.S.D. for cultivar=	62.8	53.7	26.0
L.S.D. for harvest management=	64.6	54.6	25.2

TABLE VII

PEAK *H. POSTICA* LARVAL NUMBERS ($\bar{x} \pm$ SE) AS INFLUENCED BY HARVEST AND HERBICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1986

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
WL318						
#/stem	5.4 ± 0.1	5.1 ± 0.6	4.9 ± 0.3	5.1 ± 0.4	5.3 ± 0.5	5.6 ± 0.4
#/0.1 m^2	81.2 ± 6.1	94.9 ±13.4	94.8 ±13.6	110.1 ±17.5	70.5 ± 9.8	102.6 ±20.8
Arc						
#/stem	8.0 ± 0.8	4.1 ± 0.2	3.4 ± 0.2	3.8 ± 0.3	7.4 ± 0.5	6.1 ± 0.7
#/0.1 m^2	108.9 ±13.0	71.8 ±11.7	61.2 ± 3.7	76.3 ± 7.4	101.1 ±27.6	111.7 ±11.7
OK08						
#/stem	6.3 ± 0.8	5.1 ± 0.4	5.8 ± 0.6	3.6 ± 0.2	6.8 ± 0.5	6.7 ± 0.3
#/0.1 m^2	27.0 ±12.3	57.6 ± 7.0	42.3 ±12.1	44.6 ±11.7	25.4 ± 5.2	81.6 ±21.7

	#/stem	#/0.1 m^2
L.S.D. for cultivar=	1.0	28.2
L.S.D. for harvest management=	1.0	28.3
L.S.D. for herbicides=	0.2	6.6

Table contains means for sub-subplots that received no carbofuran treatment.

TABLE VIII

H. postica EGGS/0.1 m^2 ($\bar{x}$ ± SE) AS INFLUENCED BY HARVEST MANAGEMENT IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1986-87

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
2 December 1986						
WL318	24.9 ± 7.3	67.7 ±13.1	112.8 ±31.3	166.8 ±48.5	140.3 ±23.7	188.8 ±36.7
Arc	11.0 ± 6.1	45.0 ±14.0	49.0 ±19.0	88.8 ±14.1	50.9 ±15.7	65.8 ±13.5
OK08	12.3 ± 5.5	22.8 ±11.9	5.7 ± 2.5	32.3 ±11.3	33.9 ±16.7	51.2 ±28.7
19 December 1986						
WL318	57.4 ±11.5	64.1 ±17.4	37.8 ± 9.7	29.8 ± 6.6	155.8 ±24.6	196.1 ±30.0
Arc	12.9 ± 3.8	28.2 ± 6.8	12.6 ± 5.8	5.1 ± 1.7	31.1 ± 7.0	43.7 ±13.7
OK08	15.8 ± 5.0	28.7 ±10.5	2.1 ± 1.1	4.8 ± 1.5	29.1 ±11.5	53.6 ±20.0
19 February 1987						
WL318	90.6 ±21.2	113.8 ±35.1	84.1 ±30.3	46.1 ±14.8	152.4 ±36.9	250.3 ±42.1
Arc	15.6 ± 3.6	64.8 ±16.0	15.6 ± 9.6	22.9 ± 6.5	73.3 ±14.8	95.6 ±32.0
OK08	15.1 ± 5.4	48.5 ±24.6	3.1 ± 1.7	13.4 ± 3.9	36.5 ± 8.9	55.4 ±20.5

	2 Dec.	19 Dec.	19 Feb.
L.S.D. for cultivar=	56.5	39.2	62.2
L.S.D. for harvest management=	55.2	39.0	57.6
L.S.D. for herbicides=	15.8	10.8	17.1

TABLE IX

PEAK *H. POSTICA* LARVAL NUMBERS ($\bar{x} \pm SE$) AS INFLUENCED BY HARVEST AND HERBICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1987

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
WL318						
#/stem	7.1 ± 0.4	9.0 ± 1.1	6.8 ± 0.9	6.0 ± 0.7	9.1 ± 1.6	12.4 ± 1.0
#/0.1 m^2	24.3 ±11.9	59.7 ±20.0	45.0 ± 2.5	62.6 ±21.3	41.1 ±24.0	107.6 ±64.3
Arc						
#/stem	8.7 ± 1.2	7.2 ± 0.3	5.2 ± 0.5	5.3 ± 0.6	7.9 ± 1.1	9.0 ± 1.0
#/0.1 m^2	45.3 ±15.5	50.3 ±10.3	26.7 ± 2.9	41.9 ± 6.5	29.3 ±10.2	62.4 ±20.2
OK08						
#/stem	6.2 ± 2.1	5.9 ± 0.7	2.7 ± 0.3	3.9 ± 1.0	5.0 ± 1.2	6.6 ± 0.3
#/0.1 m^2	12.2 ± 6.5	33.2 ±11.3	10.3 ± 2.9	31.1 ± 9.5	5.9 ± 3.7	42.5 ±13.7

	#/stem	#/0.1 m^2
L.S.D. for cultivar=	2.1	41.1
L.S.D. for harvest management=	2.1	34.4
L.S.D. for herbicides=	0.6	7.8

Table contains means for sub-subplots that received no carbofuran treatment.

Chapter V

ALFALFA STEM DENSITY AND WEEDS ON DYNAMICS OF ALFALFA WEEVIL POPULATIONS

Control of weeds reduces competition and allows better crop growth and enhanced stand longevity in alfalfa, *Medicago sativa* L. (Peters & Peters 1972). When weedy plants provide suitable sites for oviposition and larval development by insect pests such as the black cutworm, *Agrotis ipsilon* (Hufnagel), and variegated cutworm, *Peridroma saucia* (Hubner), removal of weeds may have the added benefit of reducing insect populations and potential loss of yield (Buntin & Pedigo 1986, Busching & Turpin 1979, Johnson et al. 1984). In contrast to these findings, the relative density of insect herbivores is frequently higher in pure stands of host plants than in those infested with weeds (Root 1973). The green peach aphid, *Myzus persicae* (Sulzer), populations develop to higher densities in weed-free collards, *Brassicae oleracea* L. cultivar= 'Georgia', than in those infested with weeds (Horn 1981). This is also true of the Mexican bean beetle, *Epilachna varivestis* Mulsant, in soybeans, *Glycine max* L. (Shelton & Edwards 1983). In Kentucky, Wolfson & Yeargan (1983) reported higher alfalfa weevil, *Hypera postica* (Gyllenhal), larval densities per 10 or 25 stems in plots treated with herbicide but indicated that both herbicide treated and untreated plots were infested to some extent with weeds. Norris et al. (1984) observed in California that the relative density of Egyptian alfalfa weevil, H. brunneipenis Bohman, was 1.2-1.5 times greater in weed-free versus weed-infested alfalfa. More alfalfa weevil larvae per stem were also found by Berberet et al. (1987) in Oklahoma but in only 1 of 5 yr.

The presence of weeds may interact directly with the alfalfa weevil in a positive way by supplying ovipositional sites to adult weevils (Ben Saad & Bishop 1969), or have indirect deleterious effects through interference with alfalfa growth and development leading to reduced habitat (Peters & Peters 1972). Encroachment of weeds into alfalfa stands usually means a reduction in suitable food material (alfalfa leaves). Therefore reductions in weevil density in weed-infested plots relative to weed-free alfalfa may be due to an increase in weed content, a decrease in alfalfa stem density, or a combination of both factors. The objective of this chapter is to document the dynamics of alfalfa stem density and weeds on alfalfa weevil populations.

Materials & Methods

This study was conducted at the South Central Research Station at Chickasha, Oklahoma on an irrigated alfalfa stand established in the fall of 1981. Data were collected from four replications of the alfalfa cultivars 'Arc' (Devine et al. 1975), 'OK08' (Oklahoma common), and 'WL318' (Beard & Kawaguchi 1978) on main plots. In strips across these main plots were subplots of harvest management options consisting of late fall harvest (November) and winter grazing (December and early January) at a stocking rate of 12-15 cattle/ha for a 2-3 wk period. The third subplot was left uncut and ungrazed to determine the potential for larval populations where fall growth remained. The final harvest of the season on these plots was taken in mid-September and was followed by 20-25 cm of fall growth.

Carbofuran insecticide and the herbicides terbacil and oryzalin were applied in a 2 x 2 factorial design on sub-subplots within each cultivar by harvest management combination. Alfalfa weevil larval populations were maintained below the economic threshold of 1.5-2.0 per stem throughout the study in sub-subplots treated with insecticide and were not included in the analyses presented in this chapter. The resulting treatment combinations included 1) the herbicides only to control weeds and allow alfalfa weevil infestation, and 2) unsprayed plots to allow infestation of both weevils and weeds. Naturally occurring insect and broadleaf weed populations were utilized until the summer of 1985 when cheat was seeded (@ 15 kg/ha) to increase the potential for weed competition during winter and spring of 1986 and 1987. Harvest and pesticide treatments were first imposed in the fall of 1982 and spring of 1983, respectively, and resulted in a wide range of stem densities and weed infestation levels by the spring of 1986.

Alfalfa weevil larval populations were sampled (25 stems) at 3 or 4 weekly intervals to determine peak densities. The sampling period was adjusted based on the evidence of feeding damage and occurrence of larvae in nearby population monitoring studies. Larvae were separated from plant material with Berlese funnels and counted.

Weed content (%) in forage was determined prior to harvesting throughout the study with visual estimates in each plot. Weed and alfalfa components were separated and weighed from 0.5 m^2 quadrats to assure accuracy of visual estimates several times throughout the study. Stem density was determined by counting stems in five 0.1 m^2 quadrats in each sub-subplot prior to harvesting in spring. Because consistent significant differences in stem densities and weed infestations among treatment combinations did not occur during the first 3 yr of the study, only data from 1986 and 1987 have been incorporated into this model.

A multiple regression model was developed utilizing the RSQUARE procedure of SAS (1985). This model incorporated alfalfa stem density in spring, the percentage of weeds in the forage at first harvest, and harvest management treatments. Alfalfa cultivars and herbicide treatments were not included because there was no evidence that these factors directly affected alfalfa weevil larval populations during this study (Chapter IV). The correlations among the independent variables were significant ($P < 0.05$). Therefore a correlation transformation was employed standardizing data to sample means and standard deviations to reduce problems associated with multicollinearity (Neter et al. 1983). The resulting regression equation was then reparameterized to the original data.

Results

The best linear model derived from the transformed data incorporating alfalfa stem density/0.1 m^2 and the percentage of weeds in the forage at first harvest did not satisfactorily predict the observed number of alfalfa weevil larvae per stem ($r^2 = 0.23$). The reparameterized model was:

$$Y = 9.24439 - 0.07957X_1 - 0.00527X_2 - 2.02025X_3 \quad (5.1)$$

where Y = the predicted number of alfalfa weevil larvae per stem,

X_1 = the number of alfalfa stems/0.1 m^2,

X_2 = the percentage of weeds in the forage at first harvest, and

X_3 = 1 if plots had been grazed during winter, or 0 otherwise.

The regression coefficients for alfalfa stem density and the indicator variable for winter grazing were significant ($t = -2.34$, $P < 0.05$; $t = -5.38$, $P < 0.001$). However, the coefficient for the percentage of weeds in the forage at first harvest was not significant ($t = -0.78$, $P > 0.05$) but was included in the model because it was one of the factors of interest.

Peak alfalfa weevil larval population density was ca. 6.2 per stem and had a range of 1.6-14.5 per stem. The number of stems/0.1 m^2 was ca. 10.1 and had a range of <1.0 to 28.2/0.1 m^2. The percentage of weeds in the forage at first harvest was ca. 46.5% with a range of <1.0 to 99.0%. Alfalfa stem density and weed content were significantly correlated ($r = -0.65$, $P < 0.01$) so equation 5.1 cannot be interpreted by holding one factor constant and varying the other across its entire range. The relationship between alfalfa stem density and the percentage of weeds is plotted for alfalfa treated and not treated with herbicides in Figure 1. Alfalfa stem density and the indicator variable for grazing in winter were also significantly correlated ($r = 0.18$, $P < 0.05$).

The magnitude of the regression coefficients for alfalfa stem density and the percentage of weeds in the forage at first harvest are close to 0 indicating that neither factor greatly influences the number of larvae per stem and resulted in a response surface that was almost parallel with the axes for alfalfa stem density and percentage of weeds (Figure 2(a)). However, the coefficient for grazing in winter indicates that peak alfalfa weevil larval populations were reduced by ca. 2 per stem compared to harvesting in late fall of not harvesting through winter (Figure 2(b)). Figure 2 should be interpreted within the limitations of alfalfa stem density and the percentage of weeds presented in Figure 1. It was never observed that both factors were at high or low levels simultaneously.

Discussion

The observed number of alfalfa weevil larvae per stem was not satisfactorily predicted by alfalfa stem density and the percentage of weeds in the forage at first harvest. As the number of alfalfa stems/0.1 m^2 decreased, the change in the number of weevil larvae per stem was small and probably of little biological importance. My findings are in contrast with those of Wolfson & Yeargan (1983) who reported greater alfalfa weevil larval populations per 10 or 25 stems in plots treated with herbicide. The change in larval density per stem was also small as the weed content of the first harvest forage changed.

Increases in the relative density (#/sweep) of alfalfa weevil larvae in weed-free versus weed-infested alfalfa as reported by Norris et al. (1984) may have occurred because plots infested with weeds had lower stem densities than those without weeds. Finding fewer weevil larvae/0.1 m^2 in plots with high weed density would be expected even though the number per stem remained relatively constant because the alfalfa stem numbers are reduced. Physical interference by weeds when sampling with a sweepnet may inhibit larval collection and result in reporting lower larval populations in weed infested plots than are actually present.

In conclusion, the number of alfalfa weevil larvae per stem was not dependent on alfalfa stand density or the weed content of the resulting forage in my study. An observed increase in the relative density of larval populations in plots with low weed infestations apparently was due to greater alfalfa stem density which offers more habitat for developing populations than plots with high weed density and fewer alfalfa stems/0.1 m^2.

References cited

Ben Saad, A. A., & G. W. Bishop 1969. Egg-laying by the alfalfa weevil in weeds. J. Econ. Entomol. 62: 1226-1227.

Berberet, R. C., J. F. Stritzke & A. K. Dowdy. 1987. Interactions of alfalfa weevil, Hypera postica (Gyllenhal) (Coleoptera: Curculionidae), and weeds in reducing yield and stand of alfalfa. J. Econ. Entomol. 80: 1306-1313.

Buntin, G. D. & L. P. Pedigo. 1986. Enhancement of annual weed populations in alfalfa after stubble defoliation by variegated cutworm (Lepidoptera: Noctuidae). J. Econ. Entomol. 79: 1507-1512.

Busching, M. K., & F. T. Turpin. 1979. Oviposition preference of black cutworm moths among various crop plants, weeds and plant debris. J. Econ. Entomol. 69: 587-590.

Horn, D. J. 1981. Effect of weedy backgrounds on colonization of collards by green peach aphid, Myzus persicae, and its major predators. Environ. Entomol. 10: 285-289.

Johnson, T. B., F. T. Turpin, M. M. Schreiber & D. R. Griffith. 1984. Effects of crop rotation, tillage, and weed management systems on black cutworm (Lepidoptera: Noctuidae) infestations in corn. J. Econ. Entomol. 77: 919-921.

Neter, J., W. Wasserman & M. H. Kutner. 1983. Applied Linear Regression Models. Richard D. Irwin, Inc. Homewood, Illinois.

Norris, R. F., W. R. Cothran & V. E. Burton. 1984. Interactions between winter annual weeds and Egyptian alfalfa weevil (Coleoptera: Curculionidae) in alfalfa. J. Econ. Entomol. 77: 43-52.

Peters, E. J. & R. A. Peters. 1972. Weeds and weed control. pp. 557-573. In C. H. Hanson [ed.], Alfalfa science and technology. Am. Soc. Agron., Madison, Wis. 812 pp.

Root, R. B. 1973. Organization of a plant-arthropod association in simple and diverse habitats: the fauna of collards (Brassica oleracea). Ecol. Monographs 43: 95-124.

SAS Users guide: statistics, version 5 edition. 1985. SAS Institute, Cary, North Carolina. 957p.

Shelton, M. D. & C. R. Edwards. 1983. Effects of weeds on the diversity and Abundance of insects in Soybeans. Environ. Entomol. 12: 296-298.

Wolfson, J. L. & K. V. Yeargan. 1983. The effects of metribuzin on larval populations of alfalfa weevil _Hypera postica_ (Coleoptera: Curculionidae). J. Kansas Entomol. Soc. 56: 40-46.

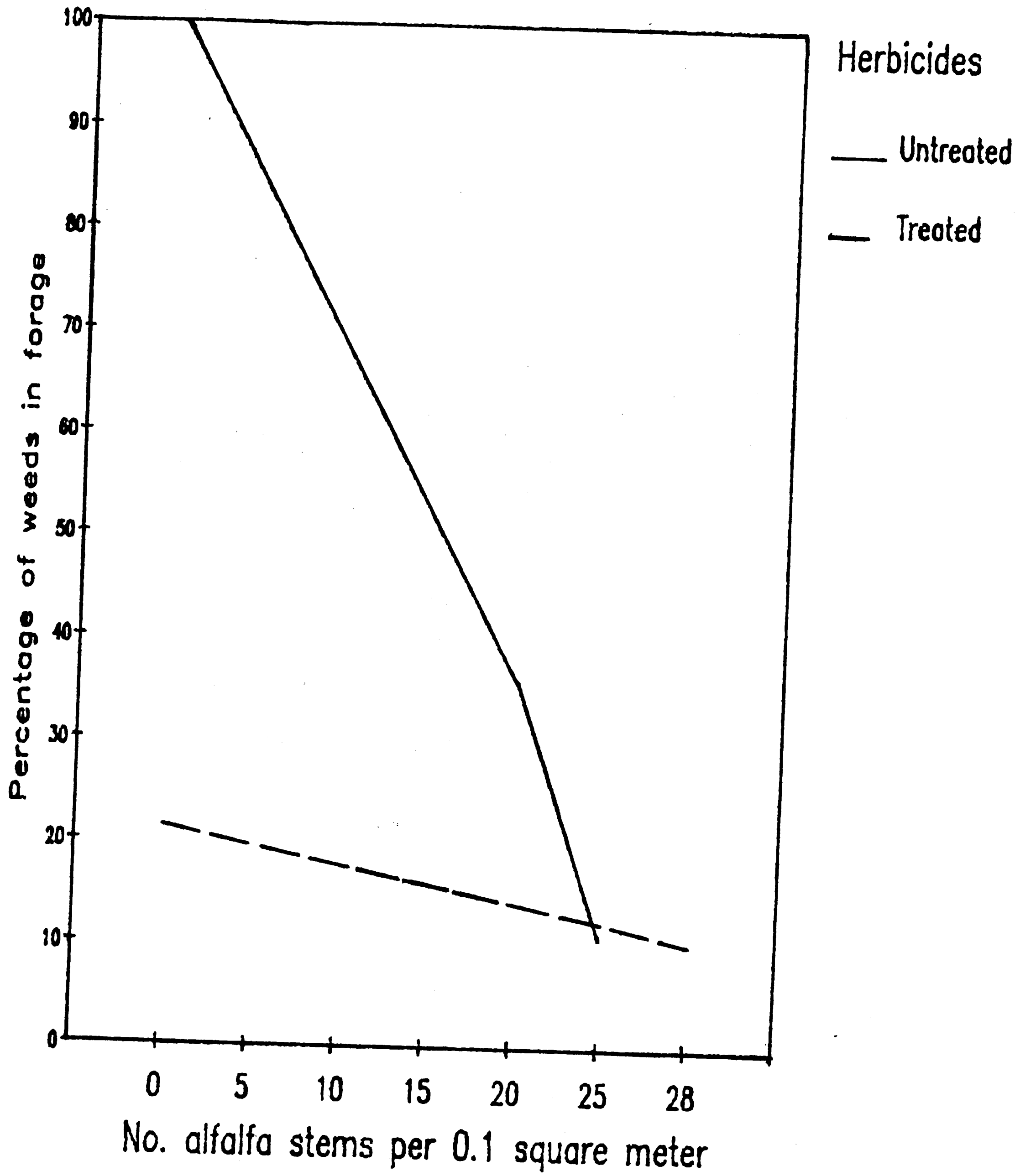

Figure 1. The relationship of alfalfa stem density in spring and the percentage of weeds in the forage at first harvest for alfalfa treated and not treated with herbicides.

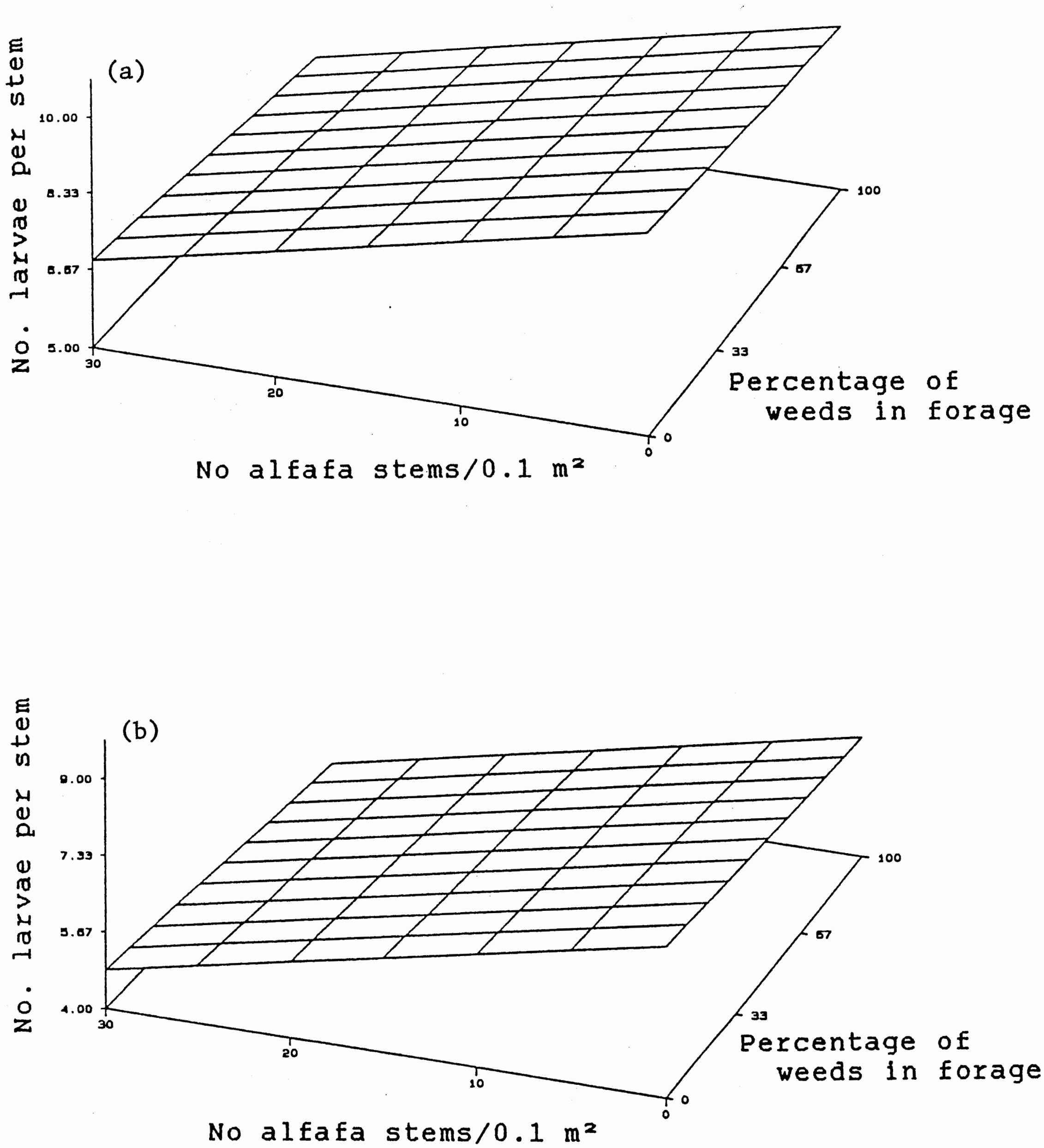

Figure 2. Response surface for peak alfalfa weevil larval populations per stem given alfalfa stem density and the percentage of weeds in the forage at first harvest. (a) harvested in late fall or left unharvested through winter, (b) winter grazed.

CHAPTER VI

EFFECTS OF FALL HARVEST MANAGEMENT AND ALFALFA WEEVILS ON TOTAL NONSTRUCTURAL ROOT CARBOHYDRATES OF ALFALFA

Root total nonstructural carbohydrates (TNC) consist of starch and sugars stored in a form readily utilizable by plants. These carbon compounds are needed as a source of energy for regrowth of alfalfa (Medicago sativa L.) until leaf area is great enough to produce carbohydrates in sufficient quantities through photosynthesis (Brown et al. 1972). Graber (1927) reported that TNC accounts for more than 40% of the dry weight of alfalfa roots during fall and winter. Additionally, a high correlation between TNC and percent dry matter (%DM) of alfalfa roots exists (Wolf 1978) but they may not be consistently correlated across sampling dates (Ogg 1988).

In order for an alfalfa plant to produce and store sufficient TNC reserves for overwintering and regrowth in spring, Grandfield (1935) felt that 20-25 cm of fall growth was necessary in Kansas. Smith (1972) listed several authors that advocate no harvesting in fall within 4-6 wk of the first killing freeze. Harvesting in fall may stimulate regrowth resulting in reduced levels of carbohydrates needed to develop cold tolerance and winterhardiness. Additionally, a harvest schedule that results in lowered TNC levels in fall and winter may also reduce crown bud development essential for spring growth (Smith 1972). In Oklahoma, Ogg (1988) and Sholar et al. (1983) reported that cutting alfalfa in November resulted in little decrease in root TNC since there was minimal regrowth prior to the onset of winter dormancy. No reductions in subsequent seasonal alfalfa production resulted from cutting in November. Ogg (1988) also reported that root TNC levels decrease throughout winter, but cutting in mid-November made little difference in winter root reserve carbohydrate trends compared to alfalfa cut in September.

In Chapter III, I reported that fall harvesting and winter grazing did not reduce alfalfa yields in subsequent years. Thus, differences in root TNC among the harvest management treatments were not anticipated. However, infestation by alfalfa weevil, Hypera postica (Gyllenhal), did lower alfalfa yields and reduced stand longevity as a result of larval feeding damage to leaf tissue. In New York, alfalfa weevil larval feeding prior to cutting in spring reduced root TNC and resulted in slower regrowth rates for subsequent alfalfa crops (Fick 1976). Root TNC levels have been reduced 0.14 Mg/ha during infestation of approximately three larvae per stem but recovery after weevil control may result in greater root reserves than in alfalfa plants where weevils were controlled (Fick & Liu 1976). This is probably due to compensatory plant growth caused by weevil feeding damage.

The objective of this chapter is to document the individual and combined effects of alfalfa weevil larval feeding damage and late fall harvest or winter grazing on root carbohydrate levels in three alfalfa cultivars.

Materials & Methods

This study was conducted at the South Central Research Station at Chickasha, Oklahoma, on an irrigated alfalfa stand established in the fall of 1981. The experimental design was a split plot in strips configuration with four replications of the alfalfa cultivars 'Arc' (Devine et al. 1975), 'OK08' (Oklahoma common), and 'WL318' (Beard & Kawaguchi 1978) on main plots. Subplots positioned in strips across the main plots were harvest management options consisting of late fall harvest (November) and winter grazing (December and early January) at a stocking rate of 12-15 cattle/ha for a 2-3 wk period. The third subplot was left uncut and ungrazed during fall and winter to determine root TNC and percent dry matter where fall growth remained through winter. The final harvest of the season on these plots was taken in mid-September after which plants produced 20-25 cm of fall growth.

Carbofuran insecticide was applied on sub-subplots within each cultivar by harvest management treatment resulting in areas with and without weevil infestations. Herbicides were applied to all treatment combinations to control weeds and did not appear to cause mortality to larvae (Chapter IV). Harvest management and pesticide treatments were first imposed in the fall of 1982 and spring 1983, respectively. However, the TNC component of the study was not initiated until the fall of 1985.

A 20-root sample was dug on 8 November (1985) from each sub-subplot treated with carbofuran to document fall root TNC levels at the time the fall harvest treatment was imposed. Samples were again dug on 14 January (1986) after grazing was completed; on 20 February, at the initiation of active alfalfa growth; and on 8 April, ca. 2 wk after peak larval densities occurred. Sampling dates for the 1986-87 season were 19 November and 19 December (1986), and 19 February and 23 April (1987). Roots were also dug from the weevil infested treatment in April each year to determine the effect of larval feeding damage on root TNC and %DM.

Alfalfa roots were soaked in ice water for ca. 2 h, washed free of soil and a section (10 cm) of each taproot was clipped below the crown and lateral roots were removed. All roots were then blotted dry and weighed to the nearest 0.01 g. Roots were heated at 100°C for 2 h to stop enzymatic activity then oven dried completely at 70°C and dry weights calculated. Percent dry matter (%DM) was calculated and used to gravimetrically determine root TNC in 1987 (Wolf 1978).

In 1986, root TNC was analyzed in the laboratory. Dried roots were first ground through a 2 mm screen then through a 0.25 mm screen to insure uniform particle size. Root TNC was extracted using amyloglucosidase and amylase for 24 h at 54°C as described by Smith (1981). Following acid hydrolysis, total nonstructural carbohydrate concentration was determined spectrophotometrically at a wavelength of 575 nm using dinitrosalicylic acid as a reducing sugar indicator (Gabrielson et al. 1985). Linear regression with starch standards was used to calculate TNC concentrations in dry root samples.

Laboratory analyses were not utilized to determine TNC content of roots sampled in 1986-87 because the sample processing according to statistical design that was necessary to make the desired comparisons would have required 3-4 months. However, %DM of roots is presented and, because of the high correlation between root TNC and %DM during 1985-86, results were expected to be very similar to those for TNC.

Larval populations were sampled based upon Celsius day degree (CDD) accumulations utilizing a developmental threshold of 10°C (Hsieh et al. 1974). The historical peak larval population occurs at about 280 CDD from 1 January for the Chickasha area (Berberet unpublished data). Samples were obtained at approximately 220, 280, and 340 CDD in an effort to obtain the best estimates of peak larval populations and detect any differences due to management practices. A 25-stem sample was taken from each sub-subplot and larvae were extracted using Berlese funnels. From these samples, the numbers of larvae per stem were calculated.

Plant height (cm) was measured in late winter or spring and prior to first harvest to detect differences due to harvest and weevil control treatments. Visual estimates of alfalfa maturity were also recorded prior to the first harvest in spring to document differences due to treatment effects.

All data were subjected to the analysis of variance procedure and F-tests were utilized to detect significant interactions among treatment components (SAS 1985). Mean separations were accomplished with least significant difference tests at the 0.05 level of probability (Steel & Torrie 1980). All data are presented by subplot or sub-subplot to facilitate communication of the effects of treatment levels between years. Therefore, calculated F values obtained through analyses of the data in a split-plot in strips configuration are not necessarily descriptive of the means presented. All F values and associated degrees of freedom are presented in Appendix B. Pearson correlation coefficients were calculated to determine the significance of correlation between TNC and %DM (SAS 1985).

Results

1985-1986

All sub-subplots were harvested on 13 September 1985 and the fall harvest was taken on 8 November. The subplots to be grazed or left unharvested through winter had ca. 38 cm of fall growth which was killed by freezing temperatures on 1

December. On 8 November, TNC and %DM averaged 28.8% and 35.0%, respectively, for all treatments and there were no significant differences among treatment combinations. Root TNC and %DM were highly correlated (r= 0.82, P= 0.0001). When sampled after grazing (14 January 1986), TNC averaged ca. 23.8% in all treatments. However, %DM of OK08 alfalfa roots was significantly lower than that for Arc in all harvest management treatments (Table I). Alfalfa roots from those subplots harvested in fall had lower %DM than from those left unharvested (in all cultivars) and less than the winter grazed subplots in Arc. This may have resulted from regrowth (photosynthesis) after the date of fall harvesting. Root TNC and %DM were highly correlated (r= 0.86, P= 0.0001).

When roots were sampled at the initiation of accelerated growth in spring (20 February), root TNC had dropped to an average of 15.9% and significant differences were not observed among cultivars or harvest management treatments. As observed in previous sampling, %DM of OK08 roots was significantly lower than in Arc (Table I). Additionally, %DM of the roots from subplots left unharvested through winter averaged significantly higher than that of the other harvest management treatments. Again, root TNC and %DM were highly correlated (r= 0.72, P= 0.0001).

Just as the %DM of roots in OK08 was generally less than the other cultivars, height of new growth, measured 25 February, of OK08 was generally less than for WL318 (Table II). Similarly, subplots harvested in fall or grazed during winter had significantly lower plant heights than those left unharvested. Although root TNC was not significantly different among harvest management treatments, the actual weight of TNC may have been greater in the unharvested treatment as indicated by the higher %DM. This resulted in more new growth of alfalfa than where %DM was lower and probably less actual weight of TNC.

Alfalfa weevil larval populations peaked ca. 11 March in 1986 and averaged less than 1.5 per stem in sub-subplots treated with carbofuran and 4.4-6.3 per stem in sub-subplots not treated. When roots were sampled 8 April, ca. 4 wk after the occurrence of peak larval density, cultivars and harvest management treatments were generally not significantly different in %DM (Table I) or root TNC concentration (Table III). However, root TNC was significantly reduced by larval feeding damage and the combination of these factors suppressed plant growth and development. Percent dry matter of alfalfa roots was not consistently affected by larval feeding damage as was expected by root TNC levels. The correlation between root TNC and %DM continued to be significant ($r = 0.65$, $P = 0.0001$).

Plant heights at first harvest, 28 April, were not significantly different among cultivars but fall harvested subplots were generally significantly shorter than the unharvested treatment even though alfalfa weevil larval populations were ca. 6 per stem in both harvest treatments (Table II). Plant heights of the sub-subplots infested with weevil larvae averaged ca. 25 cm less than the sub-subplots treated with insecticide. The percentage of blooms at first harvest was less than 5% in all sub-subplots indicating that plant maturity was similar.

1986-1987

All harvest management treatments were last cut on 16 September 1986 and the fall harvest treatment was imposed on 8 November. The subplots left unharvested or grazed during winter had ca. 34 cm of growth that was killed by freezing temperatures on 11 November. Percent dry matter of plants dug 19 November 1986 averaged ca. 23.0%. There were no significant differences among treatment combinations.

When sampled postgrazing (19 December 1986), root %DM was not significantly different among harvest management treatments. However, %DM of OK08 roots was generally less than the other cultivars (Table IV). When alfalfa roots were sampled as the growth rate increased (19 February 1987), %DM had decreased from the previous sample and neither cultivars nor harvest management treatments were significantly different (Tables IV).

Alfalfa weevil larval populations peaked ca. 28 March in 1987, and averaged 5.1 per stem in winter grazed and 7.4-9.3 per stem in the other harvest management treatments in sub-subplots not treated with carbofuran. When alfalfa roots were sampled ca. 3 wk later on 23 April, there continued to be no significant difference among cultivars or harvest management treatments (Tables IV). Even with larval populations of 6.9 per stem, there were not consistent differences between sub-subplots treated or not treated with carbofuran.

Plant heights taken on the same day were generally significantly lower in OK08 than the other cultivars (Table V). There were no significant differences in plant heights among harvest management treatments in sub-subplots treated with insecticide. However, winter grazed sub-subplots not treated with insecticide generally had significantly greater plant heights than the other harvest management treatments. Lower weevil larval populations in subplots grazed in winter may have allowed additional plant growth. By first harvest, 12 May, plant heights of cultivars or harvest management treatments were generally not significantly different (Table V). However, infestations of alfalfa weevil larvae resulted in significantly lower plant heights than sub-subplots treated with insecticide. Larval feeding damage also reduced plant maturity at first harvest and the proportion of plants blooming averaged less than 15% compared to greater than 35% bloom in sub-subplots where larvae had been controlled.

Discussion

During the winter and spring of 1985-86, root TNC and %DM determined in the laboratory were positively correlated for all sampling dates. A high correlation between TNC and %DM was also reported for alfalfa by Wolf

(1978) who determined that %DM was a good predictor of root TNC. The seasonal trend for root TNC was similar to that reported by Graumann et al. (1954) for Oklahoma. Percent dry matter of roots followed similar trends both seasons.

In both years more than 30 cm of fall growth were present to allow sufficient TNC storage for overwintering as recommended for Kansas by Grandfield (1935). Root TNC was not different among cultivars for any sampling dates in 1985-86. Percent dry matter was not different among cultivars in fall or spring. However, roots of OK08 generally had lower %DM than Arc when sampled postgrazing or at the acceleration of growth in spring. Plant heights of spring growth were similar among cultivars in 1986 but in 1987, OK08 was ca. 5 cm shorter than the other cultivars when roots were sampled on 23 April. Based on root TNC and %DM, this difference was not anticipated.

Total nonstructural root carbohydrates were similar among harvest management treatments in 1985-86. The %DM of alfalfa roots was also similar among harvest treatments in both years except on 14 January and 20 February 1986 when the roots from plants harvested in fall or winter grazed were significantly lower in %DM than subplots left unharvested through winter. These data indicate that harvesting alfalfa in November or grazing during winter while alfalfa plants are dormant does not result in additional demands on root TNC relative to alfalfa left unharvested through winter. Ogg (1988) and Sholar et al. (1983) also reported that alfalfa could be harvested in November in Oklahoma with little decrease in root TNC. However, in my study, subplots harvested in late fall tended to have shorter growth than the other harvest management treatments at first harvest, especially in 1986. This is probably due to alfalfa attempting to grow after the November harvest and depleting root TNC.

When sampled after the occurrence of peak larval populations, accumulation of root TNC was suppressed by infestations of alfalfa weevil larvae. In spite of the high correlation between root TNC and %DM, the %DM was not consistently affected by the presence or absence of weevil larvae. Root TNC and %DM were not perfectly correlated and TNC appears to be more sensitive to larval feeding damage. Plant heights in sub-subplots where weevil larvae were not controlled were ca. 24 and 13 cm shorter in 1986 and 1987, respectively, than where carbofuran had been applied prior to first harvest. Alfalfa weevil larval feeding damage inhibited plant growth by destroying plant terminals. Additionally, plant maturity at first harvest was delayed due to infestation by weevil larvae. Fick (1976) and Fick & Liu (1976) also reported that larval feeding damage reduced root TNC and resulted in a slower growth rate than in alfalfa plants that had fewer than 3 larvae per stem.

In conclusion, neither harvesting in November nor grazing in winter resulted in significantly lower root TNC or %DM when measured in spring, than in alfalfa left unharvested through winter. Feeding damage caused by alfalfa weevil larvae generally reduced root TNC accumulation in spring as compared to plants where the larvae had been controlled. Over the life of an alfalfa stand, continued stress from larval feeding damage reducing root TNC accumulation may accelerate stand decline by making alfalfa less competitive with weeds resulting in lower seasonal alfalfa production.

References cited

Berberet, R. C. R. D. Morrison & K. M. Senst. 1981. Impact of the alfalfa weevil, Hypera postica (Gyllenhal) (Coleoptera: Curculionidae), on forage production in nonirrigated alfalfa in the southern plains. J. Kansas Entomol. Soc. 54: 312-318.

Brown, R. H., R. B. Pearce, D. D. Wolf & R. E. Blaser. 1972. Energy accumulation and utilization. In Alfalfa Science and Technology. C. H. Hanson (ed.). Agronomy 15: 143-166.

Fick, G. W. 1976. Alfalfa weevil effects on regrowth of alfalfa. Agron. J. 68: 809-812.

Fick, G. W. & B. W. Y. Liu. 1976. Alfalfa weevil effects on root reserves, developmental rate, and canopy structure of alfalfa. Agron. J. 68: 595-599.

Gabrielson, B. C., D. H. Smith & C. E. Townsend. 1985. Cicer milkvetch and alfalfa as influenced by two cutting schedules. Agron. J. 77: 416-422.

Graber, L. F., N. T. Nelson, W. A. Luekel & W. B. Albert. 1927. Organic food reserves in relation to the growth of alfalfa and other perennial herbaceous plants. Wisconsin Agr. Exp. Sta. Res. Bull. 80.

Graumann, H. O., J. E. Webster, C. L. Canode & H. F. Murphy. 1954. Harvest practices on the performance of alfalfa. Okla. A. & M. Coll. Agr. Exp. Sta. Bull. No. B-433. 57p.

Nelson, C. J. & D. Smith. 1968. Growth of birdsfoot trefoil and alfalfa. III. Changes in carbohydrate reserves and growth analysis under field conditions. Crop Sci. 8: 25-28.

Ogg, J. B. 1988. Fall harvest effects on alfalfa root total nonstructural carbohydrates and percent dry matter. Master's Thesis, Oklahoma State University, 81p.

Sholar, R., J. Caddel. L. Rommann, J. Stritzke, G. Johnson, D. Schwab, S. Coppock, R. Berberet, E. Williams, W. Bowers, & T. Shaklee. 1982. Alfalfa production and pest management in Oklahoma. Oklahoma St. Univ. Coop. Ext. Circ. E-826.

Smith, D. 1972. Cutting schedules and maintaining pure stands. In Alfalfa Science and Technology. C. H. Hanson (ed.). Agronomy 15: 481-496.

Smith, D. 1981. Removing and analyzing total nonstructural carbohydrates from plant tissue. Wisconsin Agr. Exp. Sta. Res. Rep. R-2107.

Wolf, D. D. 1978. Nonstructural carbohydrate and dry matter relationships in alfalfa tap roots. Crop Sci. 18: 690-692.

TABLE I

PERCENT DRY MATTER OF ROOTS ($\bar{x}$ ± SE) OF THREE ALFALFA CULTIVARS AS INFLUENCED BY HARVEST MANAGEMENT AND *H. POSTICA* INFESTATION, CHICKASHA, OKLAHOMA, 1986

Cultivar	Fall harvested	Winter grazed	Unharvested
		14 January	
WL318	31.2 ± 0.3	32.5 ± 0.3	33.6 ± 0.3
Arc	32.0 ± 0.1	33.7 ± 0.3	34.5 ± 0.6
OK08	30.4 ± 0.5	31.3 ± 0.3	32.1 ± 0.5
		20 February	
WL318	28.6 ± 0.4	29.1 ± 0.4	30.5 ± 0.3
Arc	29.2 ± 0.1	30.3 ± 0.3	31.2 ± 0.2
OK08	28.4 ± 0.3	28.2 ± 0.2	30.0 ± 0.2
		8 April	
WL318			
No insect.	28.4 ± 0.5	30.7 ± 0.6	29.8 ± 0.2
Insecticide	29.3 ± 0.3	30.3 ± 0.4	29.1 ± 0.5
Arc			
No insect.	28.4 ± 0.2	30.5 ± 0.6	29.6 ± 0.5
Insecticide	27.9 ± 0.4	29.1 ± 0.4	29.0 ± 0.4
OK08			
No insect.	27.0 ± 0.3	27.9 ± 0.5	27.9 ± 0.6
Insecticide	28.2 ± 0.7	27.6 ± 0.3	28.9 ± 0.6

	14 Jan.	20 Feb.	8 Apr.
L.S.D. for cultivar=	1.3	0.6	3.4
L.S.D. for harvest mgmt.=	1.3	0.5	2.8
L.S.D. for insecticide=	-	-	0.4

TABLE II

PLANT HEIGHTS ($\bar{x} \pm$ SE) OF THREE ALFALFA CULTIVARS AS INFLUENCED BY HARVEST MANAGEMENT AND *H. POSTICA* INFESTATION, CHICKASHA, OKLAHOMA, 1986

Cultivar	Fall harvested	Winter grazed	Unharvested
	25 February		
WL318	3.8 ± 0.1	4.4 ± 0.3	5.1 ± 0.3
Arc	3.4 ± 0.1	3.8 ± 0.3	4.4 ± 0.2
OK08	3.3 ± 0.4	3.4 ± 0.3	3.8 ± 0.2
	28 April		
No insect.	29.6 ± 1.2	31.9 ± 1.4	30.0 ± 1.3
Insecticide	53.6 ± 1.2	55.0 ± 1.3	57.0 ± 1.2

	25 Feb.	28 Apr.
L.S.D. for cultivar=	0.6	-
L.S.D. for harvest mgmt.=	0.3	3.8
L.S.D. for insecticide=	-	1.7

Measurements in cm.

TABLE III

PERCENT TOTAL NONSTRUCTURAL ROOT CARBOHYDRATES ($\bar{X} \pm$ SE) OF THREE ALFALFA CULTIVARS AS INFLUENCED BY HARVEST MANAGEMENT AND *H. POSTICA* INFESTATION, CHICKASHA, OKLAHOMA, 8 APRIL 1986

	Fall harvested	Winter grazed	Unharvested
No insect.	16.2 ± 0.8	19.0 ± 0.9	17.3 ± 1.1
Insecticide	21.6 ± 1.1	21.8 ± 0.9	21.5 ± 0.8

L.S.D. for harvest mgmt.= 3.4
L.S.D. for insecticide= 1.1

TABLE IV

PERCENT DRY MATTER OF ROOTS ($\bar{x} \pm$ SE) OF THREE ALFALFA CULTIVARS AS INFLUENCED BY HARVEST MANAGEMENT AND *H. POSTICA* CONTROL, CHICKASHA, OKLAHOMA, 1986-1987

Cultivar	Fall harvested	Winter grazed	Unharvested
	19 December		
WL318	30.0 ± 0.1	29.2 ± 0.5	28.7 ± 0.8
Arc	29.7 ± 0.4	29.1 ± 0.9	31.1 ± 0.4
OK08	28.1 ± 0.4	27.6 ± 0.5	28.3 ± 0.5
	19 February		
No insect.	28.1 ± 0.3	27.6 ± 0.3	28.4 ± 0.7
Insecticide	27.8 ± 0.3	27.0 ± 0.3	28.0 ± 0.3
	23 April		
WL318			
No insect.	27.9 ± 1.0	28.6 ± 0.5	27.3 ± 0.6
Insecticide	27.4 ± 0.4	27.6 ± 0.5	28.3 ± 1.2
Arc			
No insect.	28.2 ± 0.9	28.5 ± 0.8	28.2 ± 0.9
Insecticide	28.0 ± 0.7	29.8 ± 0.8	27.8 ± 1.2
OK08			
No insect.	27.6 ± 1.0	28.1 ± 0.6	27.0 ± 1.0
Insecticide	28.2 ± 1.1	27.7 ± 0.7	27.8 ± 1.0

	19 Dec.	19 Feb.	23 Apr.
L.S.D. for cultivar=	1.6	-	4.1
L.S.D. for harvest mgmt.=	2.3	6.5	3.4
L.S.D. for insecticide=	-	0.6	0.6

TABLE V

PLANT HEIGHTS ($\bar{x} \pm$ SE) OF THREE ALFALFA CULTIVARS AS INFLUENCED BY HARVEST MANAGEMENT AND *H. POSTICA* INFESTATION, CHICKASHA, OKLAHOMA, 1987

Cultivar	Fall harvested	Winter grazed	Unharvested
		22 April	
WL318			
No insect.	20.7 ± 2.2	28.3 ± 2.6	18.5 ± 1.5
Insecticide	30.8 ± 4.0	32.7 ± 1.8	31.4 ± 2.0
Arc			
No insect.	21.2 ± 1.0	28.7 ± 2.0	21.5 ± 1.7
Insecticide	33.4 ± 2.3	34.6 ± 3.4	31.3 ± 2.2
OK08			
No insect.	17.4 ± 2.7	22.5 ± 2.3	19.0 ± 1.4
Insecticide	25.5 ± 4.3	27.0 ± 1.9	24.4 ± 1.7
		5 May	
WL318			
No insect.	49.0 ± 2.4	54.6 ± 2.6	48.0 ± 1.6
Insecticide	61.0 ± 2.9	65.1 ± 4.1	62.5 ± 2.2
Arc			
No insect.	49.1 ± 2.2	55.5 ± 1.9	47.7 ± 0.6
Insecticide	64.7 ± 0.6	66.5 ± 5.7	67.8 ± 0.6
OK08			
No insect.	43.0 ± 3.9	47.8 ± 3.5	42.9 ± 1.4
Insecticide	54.0 ± 8.0	58.9 ± 3.2	52.5 ± 2.4

	22 Apr.	5 May
L.S.D. for cultivar=	5.4	8.7
L.S.D. for harvest mgmt.=	4.8	7.8
L.S.D. for insecticide=	1.1	1.8

CHAPTER VII

ECONOMICS OF FALL HARVEST AND WINTER GRAZING IN ALFALFA PRODUCTION

Alfalfa, *Medicago sativa* L., is the second most important agricultural crop in Oklahoma and generates over $100 million annually from ca. 200,000 ha in alfalfa production (Sholar et al. 1982). Additionally, it is an important component in the beef, dairy and horse industries. Utilization of alfalfa as a protein source can potentially reduce the cost of animal production. For example, replacing cottonseed meal or soybean meal in a dairy ration with alfalfa can save ca. $0.19/kg of crude protein.[1] Willett (1983) developed a formula for calculating the dollar value of forages to compare with other feeds based on percent crude protein and dry matter. Although this gives a good economic comparison of forage value based on protein, the actual price is dictated by supply and demand in the market place.

Generally, the actual price of alfalfa is undervalued relative to its feed value. However, recent advancements in alfalfa marketing have resulted in premium prices for high quality alfalfa forage (Ward et al. 1984). Obtaining a

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[1] Calculations based on prices for cottonseed meal, 41% crude protein (CP), $ 0.26/kg; soybean meal, 44% CP, $ 0.28/kg; alfalfa, 20% CP, $88.24/Mg (Anonymous).

premium price helps to offset the costs of insect and weed controls necessary to maintain high quality in alfalfa forage (Ward 1985). Control of insect pests, such as the alfalfa weevil, Hypera postica (Gyllenhal), and weeds, such as cheat, Bromus secalinus L., can help to maintain seasonal alfalfa production at high levels and improve stand retention relative to alfalfa where neither pest type is controlled (Chapter III). Berberet et al. (1987) reported losses of 2.0 and 0.4 Mg/ha/yr due to infestation by alfalfa weevils and weeds, respectively, and a loss of 3.7 Mg/ha/yr where neither pest type was controlled. At a price of $88.24/Mg for alfalfa hay, annual yield losses resulted in $176.00 and $35.30/ha less where alfalfa weevils or weeds were not controlled, respectively, and $326.49/ha less where neither pest type was managed.

Another method of increasing seasonal alfalfa production and possibly reducing average cost/Mg is utilization of fall growth after the last regular harvest in September. Neither harvesting in late fall nor winter grazing have been found detrimental to stand retention, relative to alfalfa left unharvested through winter. Both practices have potential of increasing annual production on a given hectarage (Chapter III). The objectives of this study were to determine if the cost of alfalfa weevil and weed controls was justified by savings in alfalfa production in three alfalfa cultivars harvested in fall or grazed in winter.

Materials & Methods

This study was conducted at the South Central Research Station at Chickasha, Oklahoma on an irrigated alfalfa stand established in the fall of 1981. The experimental design was a split plot in strips configuration with four replications of the alfalfa cultivars 'Arc' (Devine et al. 1975), 'OK08' (Oklahoma common), and 'WL318' (Beard & Kawaguchi 1978) on main plots. Subplots positioned in strips across the main plots received harvest management treatments consisting of late fall harvest (November) and winter grazing (December and early January) at a stocking rate of 12-15 cattle/ha for a 2-3 wk period. The third treatment was left uncut and ungrazed for comparison of economic returns of harvest management treatments. The final harvest of the season on these subplots was taken in mid-September.

Carbofuran insecticide and the herbicides terbacil and oryzalin were applied annually in a 2 x 2 factorial design on sub-subplots within each cultivar by harvest management combination. The resulting treatment combinations included 1) insecticide only to control weevils and allow weed infestation, 2) the herbicides only to control weeds and allow alfalfa weevil infestation, 3) both insecticide and herbicides to create a "pest-free" treatment, and 4) unsprayed plots to allow infestation of both weevils and weeds. Naturally occurring insect and weed populations were utilized until the summer of 1985 when cheat was seeded (@ 15 kg/ha) to increase the potential for weed competition during winter and spring of 1986 and 1987. Harvest and pesticide treatments were first imposed in the fall of 1982 and spring of 1983, respectively.

Four or five harvests were made each summer at 10-30% bloom stage with yields estimated from a 1 x 5 m area of each sub-subplot with a flail-type harvester. The amounts of forage removed with the late fall harvesting and winter grazing were calculated from 0.5 m^2 quadrat samples collected at the time of the late harvest.

Weed content (%) in forage was determined throughout the study with visual estimates in each plot. These estimates were used to calculate the weight of weeds and alfalfa produced/ha. At several times throughout the study, weed and alfalfa components were separated and weighed from 0.5 m^2 quadrats to assure accuracy of visual estimates.

The dollar value of alfalfa was based on the 6 yr average (1982-1987) for Oklahoma of $88.24/Mg (Anonymous). Alfalfa hay value was determined for each harvest and discounted for the content of weeds in the forage (Table I). Annual gross values ($/ha and $/Mg) were calculated from the resulting discounted value and total forage yield/ha. The dollar value of forage removed by fall harvesting and winter grazing was determined in the same manner as for regular harvests.

Treatment costs were determined for each treatment combination. To isolate the economic effects of the various treatment combinations, fixed costs (such as taxes and depreciation) and other traditional variable costs (such as repair costs and fuel costs) were considered as equal for all treatment combinations. Cost of insecticide and application expense to control alfalfa weevils was estimated to be $46.95/ha/yr. Herbicide costs for control of broadleaf and grassy weeds were estimated at $81.55/ha/yr and combined herbicides plus insecticide treatment cost $128.50/ha/yr.

The cost of the fall harvest management treatment was dependent on yield. Total cost per harvest for cutting was $18.53/ha plus $25.60/Mg for baling and hauling (Ward 1988). Any costs associated with grazing were not included as a cost against alfalfa production because these would be more directly associated with a livestock enterprise. Seed cost ($/kg) for WL318, Arc and OK08 were 5.39, 3.30 and 3.08, respectively.[2] Seed cost/ha was calculated based on a seeding rate of ca 9.1 kg/ha and the difference in costs of WL318 and Arc from OK08 was depreciated equally over the 5 yr of the study. The adjusted forage value was determined by subtracting treatment costs from gross value. Average treatment cost/Mg was calculated by dividing annual treatment costs/ha by forage yield (Mg/ha).

All data were subjected to the analysis of variance procedure and F-tests were utilized to detect significant interactions between treatment components (SAS 1985). Mean separations were accomplished with least significant

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[2] Source: Steve Calhoun, Ross Seed Company, Chickasha, Oklahoma, 31 March 1988.

difference test at the 0.05 level of probability (Steel & Torrie 1980). All data are presented by subplot or sub-subplot to facilitate communication of the effects of treatment levels over years. Therefore, calculated F values obtained through analyses of the data in a split-plot in strips configuration are not necessarily descriptive of the means presented for main plots or subplots. All F values and associated degrees of freedom are presented in Appendix B.

Results

1983

Four harvests were made during the spring and summer of 1983. Seasonal total forage yields and the percentage of weeds in the forage are presented in Chapter III to which the reader is referred. Annual total forage yield was comparable among cultivars and weed infestations were minimal. The gross forage values ($/Mg and $/ha) were generally significantly lower in sub-subplots left unharvested through winter and not treated with insecticide than the other harvest management treatments (Table II). Average treatment costs/Mg were significantly higher in subplots harvested in fall than that of the other harvest management treatments. However, adjusted value/Mg was generally not significantly less than for the other harvest management treatments. Adjusted value/Mg was significantly higher in subplots grazed in winter than those left unharvested (Table II).

The gross dollar values of forage produced/Mg and /ha were not consistently higher due to control of alfalfa weevils (Table II). Because peak alfalfa weevil larval populations occurred ca. 1 wk prior the first harvest and weed content was low (Chapter IV) there were minimal savings to be gained from the pesticide applications. Gross and adjusted dollars value were significantly increased by application of herbicides. Average costs/Mg were significantly greater due to treatment with insecticides or herbicides but did not result in consistently lower adjusted dollar values/Mg or /ha (Table II).

1984

A total of four harvests were made during the spring and summer of 1984. Among sub-subplots not treated with herbicides, those grazed in winter generally had significantly greater gross and adjusted values/Mg than those left unharvested through winter (Table III). Again, average treatment costs/Mg were significantly greater in subplots harvested in late fall than the other harvest management treatments. The additional income generated from the forage harvested in fall did not offset the additional harvesting costs that were incurred. Average treatment costs were consistently greater when insecticide or herbicides were applied and no clear economic benefits were evident (Table III). Alfalfa weevil larval populations were below 1.5 per stem in all treatment combinations which was below the economic threshold. Similarly, weed infestations in sub-

subplots not treated with herbicides were comparable to those that were treated. Annual gross and adjusted dollar value of forage produced per ha were not significantly different among cultivars or harvest management treatments.

1985

A total of five harvests were made during spring and summer of 1985. Annual gross and adjusted forage values ($/Mg and $/ha) and average costs/Mg were generally not significantly different among cultivars (Table IV).

Gross and adjusted forage values were generally not significantly different among harvest management treatments (Table IV). The entire research area was accidentally oversprayed with parathion by an aerial applicator prior to any larval sampling in spring. Applications of carbofuran insecticide had been made previously to appropriate sub-subplots and there were readily apparent differences in alfalfa weevil damage in theses and the unsprayed sub-subplots prior to the overspray. The carbofuran treatment did result in consistent significant increases in gross value/Mg and gross and adjusted forage values/ha. However, adjusted value/Mg after average treatment costs were deducted was not consistently increased by control of alfalfa weevil larvae. There was still no consistent benefit from application of herbicides even though the weed content was reduced.

1986

Four harvests were made during the spring and summer of 1986. The value of the forage produced by OK08 ($/Mg and $/ha) was significantly lower than for the other cultivars due to the high weed content in all treatment combinations (Table V). OK08 not only had lower seasonal forage yield than the other cultivars but reduced quality of the forage. There were no significant differences in the value of forage produced by WL318 and Arc.

Gross and adjusted values/Mg were generally significantly greater for subplots grazed in winter than for those left unharvested even though seasonal forage yield and weed content were comparable (Chapter III). However, annual gross and adjusted forage values/ha were not consistently different among harvest management treatments (Table V).

In sub-subplots not treated with insecticide, peak larval densities averaged 5.7 and 6.3 larvae per stem in fall harvested and unharvested subplots, respectively, while those in the winter grazed treatment averaged 4.4 per stem. Sub-subplots treated with insecticide attained peak larval populations of less than 1.5 larvae per stem. Control of alfalfa weevil larval populations in spring and the residual benefits of effective control in previous years resulted in significantly higher forage values produced/Mg and /ha for sub-subplots treated with insecticide (Table V). Similarly, control of weeds significantly increased gross and adjusted values of forage produced/Mg and /ha. This indicates for the first time in the study that the costs of insecticide and herbicides were justified by consistently greater income/ha and the production of a higher quality forage than where either pest type was not managed.

1987

Four harvests were made during the spring and summer of 1987 after which the study was terminated. Increased weed content combined with lower alfalfa yields in OK08 resulted in significantly lower annual gross and adjusted forage values/Mg and /ha than for WL318 (Table VI). Arc had intermediate values.

Harvest management treatments were not consistently different in forage values/Mg or /ha. Additionally, the average costs/Mg were generally not significantly higher in subplots harvested in fall because no additional costs were incurred in that year.

Peak alfalfa weevil larval populations of 6.5-7.2 per stem occurred in sub-subplots not treated with insecticide compared to 1.8 per stem in treated sub-subplots. The weed content of the forage produced in 1987 was ca. 20 and 50% in sub-subplots treated and not treated with herbicides, respectively, in WL318 and Arc while OK08 averaged more than 55%. Applications of insecticide or herbicides resulted in generally significantly higher gross and adjusted income from forage produced per ha and value/Mg (Table VI). Control of alfalfa weevils and/or weeds throughout the study resulted in more forage worth a higher dollar value/ha and /Mg.

1983-1987 Study total

A total of 22 harvests were made during the years of this study and fall harvesting and winter grazing treatments imposed four times. The total gross and adjusted values/ha were also generally significantly less for OK08 than for the other cultivars (Table VII). Total treatment costs for WL318 and Arc were ca. $24.10 and $4.40/ha greater, respectively, than for OK08 due to seed costs but were justified by returns greater than the additional cost of the seed.

The total gross and adjusted dollar values for forage produced/ha was typically not significantly different among harvest management treatments (Table VII). However, the total cost/ha of harvesting in fall was consistently greater than for the other harvest management treatments. Total costs/ha for winter grazing or the unharvested treatments were equal and constant throughout the study. Control of alfalfa weevils or weeds generally resulted in significantly higher gross and adjusted values for forage produced/ha (Table VII). Control of alfalfa weevils and weeds justified the higher cost/ha incurred by applications of insecticide and/or herbicides.

Discussion

The annual gross and adjusted values of forage produced/ha were not consistently different among cultivars until 1986 at which time the gross value of OK08 was reduced by ca. $375/ha due to less alfalfa production and increased weed content in all treatment combinations. OK08 has no resistance to insect pests or root rotting pathogens (that were present in this study but not quantified) whereas both WL318 and Arc have some resistance (Beard & Kawaguchi 1978, Devine et al. 1975).

Only in 1983 was the late fall harvest treatment profitable. Grazing in winter, however, tended to result in a value ca. $6/Mg higher than the unharvested treatment, particularly in 1983 and 1986. This may have been due to a slightly lower weed content in subplots that were grazed than those left unharvested through winter. The total value of forage produced/ha for the 5 yr period was not different among harvest management treatments. Throughout the study, average treatment costs/Mg were consistently higher due to harvesting in fall but generally did not result in significantly lower income/Mg or /ha. However, additional costs of production that were not addressed in this study, such as depreciation on equipment and the difficulties associated with actually getting hay dried and baled should be considered before recommending this management practice to producers.

Annual gross values for forage produced averaged ca. $3/Mg and $122/ha higher with control of alfalfa weevils and was economically beneficial as indicated by greater dollar values for forage after treatment costs were subtracted. The value of weed control appeared to be questionable in 1983 and 1984 due to low weed content in the forage from all treatment combinations. It may have been possible to delay the first applications of herbicides until February or March of 1985. However, the beneficial effects of weed control during the first 2 yr of the study became quite evident as the productivity of this treatment averaged more than $3/Mg and $150/ha greater than those not treated with herbicides in 1986 and 1987.

In conclusion, utilization of improved cultivars such as WL318 and Arc were important in maintaining profitable stands of alfalfa relative to OK08, an unimproved cultivar. Harvesting in late fall or winter grazing did not generally increase the annual dollar value of forage produced/ha compared to not harvesting through winter. However, grazing tended to increase the forage value/Mg relative to alfalfa left unharvested probably due to lower weed content. Finally, control of weeds and alfalfa weevils was important in maintaining the production of forage with a higher dollar value than no controls even after costs for insecticide and herbicides were deducted.

References cited

Anonymous. Agricultural Prices USDA-SRS. Prices Paid by Oklahoma Farmers.

Beard, D. F., & I. I. Kawaguchi. 1978. Registration of WL311 and WL318 alfalfa cultivars. (Reg. Nos. 85 86). Crop Sci. 18: 523.

Berberet, R. C., J. F. Stritzke, & A. K. Dowdy, 1987. Interactions of alfalfa weevil and weeds in reducing yield and stand of alfalfa. J. Econ. Entomol. 80: 1306-1313.

Devine, T. E., R. H. Ratcliffe, C. M. Rinker, D. K. Barnes, S. A. Ostazeski, T. H. Busbice, C. H. Hanson, J. A. Schillinger, G. R. Buss, & R. W. Cleveland. 1975. Registration of Arc alfalfa. (Reg. No. 76). Crop Sci. 15: 97.

SAS Users guide: statistics, version 5 edition. 1985. SAS Institute, Cary, North Carolina. 957p.

Sholar, R., J. Caddel, L. Rommann, J. Stritzke, G. Johnson, D. Schwab, S. Coppock, R. C. Berberet, E. Williams, W. Bowers, T. Shaklee. 1982. Alfalfa production and pest management in Oklahoma. Okla. St. Univ. Circ. E-826. 31p.

Steel, R. G. D. & J. H. Torrie. 1980. Principles and Procedures of Statistics: a Biometric Approach. 2nd Ed. McGraw-Hill Book Co., Inc. New York.

Ward, C. E. 1985. HAYMARKET Update: implications for alfalfa management. Okla. St. Univ. Curr. Rep. CR-166. 5p.

Ward, C. E. 1988. Unpublished alfalfa enterprise budget for southwestern Oklahoma. Dep. of Agric. Econ., Okla. St. Univ. Stillwater, OK 74078.

Ward, C. E., G. W. Cuperus & L. Rommann. 1984. HAYMARKET: A first year summary. Okla. St. Univ. Curr. Rep. CR-477. 4p.

Willett, G. S. 1983. What's a fair forage price? Dairy Herd Manage. 20: 21-22.

TABLE I

ALFALFA HAY PRICES DISCOUNTED FOR CONTENT OF FOREIGN MATERIAL[1]

Percent foreign material	Discount ($/Mg)	Forage value ($/Mg)
0	0.00	88.24
< 2	6.29	81.95
2-4	12.58	75.66
5-14	18.87	69.37
15-24	25.16	63.08
25-34	31.45	56.79
35-50	37.74	50.50
> 50	40.03	48.21

[1] Adapted from Ward (1988).

TABLE II

SEASONAL FORAGE VALUE ($\bar{x}$ ± SE) OF ALFALFA AS INFLUENCED BY HARVEST AND PESTICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1983, SEASON 1

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Gross value ($/Mg)			
No insect.	82 ± 1	88 ± 1	82 ± 1	87 ± 1	76 ± 1	82 ± 1
Insecticide	84 ± 1	88 ± 1	85 ± 1	88 ± 1	78 ± 1	82 ± 1
			Average cost ($/Mg)			
No insect.	2.9 ± 0.1	8.2 ± 0.3	0.1 ± 0.1	5.3 ± 0.1	0.1 ± 0.1	5.5 ± 0.1
Insecticide	5.8 ± 0.2	11.1 ± 0.5	3.1 ± 0.1	8.2 ± 0.1	3.0 ± 0.1	8.0 ± 0.2
			Adjusted value ($/Mg)			
No insect.	80 ± 1	79 ± 1	82 ± 1	82 ± 1	76 ± 1	76 ± 1
Insecticide	78 ± 1	77 ± 1	82 ± 1	80 ± 1	75 ± 1	74 ± 1
			Gross value ($/ha)			
No insect.	1373 ± 46 (16.6)[a]	1396 ± 48 (15.9)	1229 ± 34 (15.1)	1382 ± 30 (15.8)	1165 ± 29 (14.3)	1243 ± 26 (14.1)
Insecticide	1377 ± 44 (16.4)	1424 ± 56 (16.2)	1335 ± 37 (15.8)	1401 ± 27 (15.9)	1294 ± 46 (15.6)	1335 ± 40 (15.2)

TABLE II (Continued)

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/ha)			
No insect.	1326 ± 46	1267 ± 48	1227 ± 34	1298 ± 30	1163 ± 29	1160 ± 26
Insecticide	1283 ± 44	1248 ± 56	1286 ± 37	1271 ± 27	1246 ± 46	1205 ± 40

	Gross $/Mg	Avg. cost $/Mg	Adj. $/Mg	Gross $/ha	Adj. $/ha
LSD for harvest management=	3	0.8	3	147	147
LSD for pesticide=	1	0.2	1	34	34

[a] Numbers in parenthesis indicate seasonal total forage production (Mg/ha).

TABLE III

SEASONAL FORAGE VALUE ($\bar{x}$ ± SE) OF ALFALFA AS INFLUENCED BY HARVEST AND PESTICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1984, SEASON 2

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Gross value ($/Mg)			
No insect.	83 ± 1	88 ± 1	87 ± 1	88 ± 1	82 ± 1	86 ± 1
Insecticide	86 ± 1	88 ± 1	88 ± 1	88 ± 1	84 ± 1	85 ± 1
			Average cost ($/Mg)			
No insect.	1.8 ± 0.1	6.2 ± 0.2	0.1 ± 0.1	4.4 ± 0.2	0.1 ± 0.1	4.5 ± 0.1
Insecticide	4.2 ± 0.1	8.5 ± 0.2	2.7 ± 0.1	6.8 ± 0.2	2.5 ± 0.1	6.6 ± 0.2
			Adjusted value ($/Mg)			
No insect.	81 ± 1	82 ± 1	87 ± 1	84 ± 1	82 ± 1	81 ± 1
Insecticide	81 ± 1	80 ± 1	85 ± 1	82 ± 1	82 ± 1	79 ± 1
			Gross value ($/ha)			
No insect.	1652 ± 76 (19.9)[a]	1669 ± 63 (19.0)	1686 ± 86 (19.4)	1705 ± 60 (19.3)	1533 ± 66 (18.1)	1607 ± 46 (18.3)
Insecticide	1682 ± 64 (19.7)	1706 ± 55 (19.3)	1598 ± 46 (18.2)	1710 ± 45 (19.4)	1647 ± 53 (19.0)	1686 ± 56 (19.3)

TABLE III (Continued)

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/ha)			
No insect.	1617 ± 76	1553 ± 62	1685 ± 86	1622 ± 60	1531 ± 66	1524 ± 47
Insecticide	1600 ± 63	1543 ± 54	1549 ± 46	1580 ± 44	1598 ± 53	1556 ± 56

	Gross $/Mg	Avg. cost $/Mg	Adj. $/Mg	Gross $/ha	Adj. $/ha
LSD for harvest management=	3	0.7	3	281	281
LSD for pesticide=	1	0.1	1	59	59

[a] Numbers in parenthesis indicate seasonal total forage production (Mg/ha).

TABLE IV

SEASONAL FORAGE VALUE ($\bar{x}$ ± SE) OF ALFALFA AS INFLUENCED BY HARVEST AND PESTICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1985, SEASON 3

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Gross value ($/Mg)			
No insect.	72 ± 3	79 ± 2	80 ± 2	79 ± 3	75 ± 2	77 ± 2
Insecticide	78 ± 3	81 ± 2	82 ± 2	83 ± 1	78 ± 2	76 ± 3
			Average cost ($/Mg)			
No insect.	1.9 ± 0.1	5.6 ± 0.1	0.1 ± 0.0	3.9 ± 0.1	0.1 ± 0.0	3.7 ± 0.1
Insecticide	4.1 ± 0.1	7.7 ± 0.2	2.1 ± 0.0	5.7 ± 0.1	2.2 ± 0.1	5.7 ± 0.2
			Adjusted value ($/Mg)			
No insect.	70 ± 3	73 ± 2	80 ± 2	75 ± 3	75 ± 2	73 ± 2
Insecticide	74 ± 3	73 ± 2	80 ± 2	77 ± 1	76 ± 2	70 ± 3
			Gross value ($/ha)			
No insect.	1616 ± 87 (22.3)[a]	1724 ± 60 (21.9)	1776 ± 81 (22.2)	1720 ± 103 (21.7)	1636 ± 98 (20.9)	1718 ± 76 (21.6)
Insecticide	1718 ± 104 (21.9)	1801 ± 71 (22.2)	1905 ± 71 (23.1)	1889 ± 58 (22.8)	1765 ± 70 (21.7)	1746 ± 101 (22.1)

TABLE IV (Continued)

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/ha)			
No insect.	1575 ± 86	1601 ± 60	1775 ± 81	1637 ± 102	1635 ± 98	1635 ± 76
Insecticide	1629 ± 103	1631 ± 71	1856 ± 71	1759 ± 58	1717 ± 70	1616 ± 100

	Gross $/Mg	Avg. cost $/Mg	Adj. $/Mg	Gross $/ha	Adj. $/ha
LSD for harvest management=	6	0.4	6	236	236
LSD for pesticide=	1	0.1	1	54	54

[a] Numbers in parenthesis indicate seasonal total forage production (Mg/ha).

TABLE V

SEASONAL FORAGE VALUE ($\bar{x}$ ± SE) OF ALFALFA AS INFLUENCED BY HARVEST AND PESTICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1986, SEASON 4

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Gross value ($/Mg)			
WL318						
No insect.	56 ± 1	70 ± 3	64 ± 2	75 ± 3	54 ± 1	67 ± 3
Insecticide	67 ± 1	78 ± 3	72 ± 2	79 ± 1	63 ± 1	72 ± 2
Arc						
No insect.	51 ± 2	65 ± 1	58 ± 1	74 ± 2	51 ± 3	63 ± 5
Insecticide	63 ± 3	73 ± 1	68 ± 2	75 ± 3	59 ± 3	70 ± 2
OK08						
No insect.	48 ± 1	55 ± 3	48 ± 2	60 ± 1	44 ± 1	56 ± 3
Insecticide	52 ± 3	62 ± 5	54 ± 2	67 ± 2	50 ± 4	57 ± 2
			Average cost ($/Mg)			
WL318						
No insect.	2.8 ± 0.2	8.2 ± 0.4	0.3 ± 0.1	5.5 ± 0.2	0.3 ± 0.1	5.5 ± 0.1
Insecticide	5.5 ± 0.3	11.0 ± 0.5	3.1 ± 0.2	7.5 ± 0.2	2.7 ± 0.1	7.3 ± 0.3
Arc						
No insect.	2.3 ± 0.2	8.7 ± 0.4	0.1 ± 0.1	5.0 ± 0.2	0.1 ± 0.1	5.0 ± 0.2
Insecticide	4.8 ± 0.1	10.3 ± 0.3	2.7 ± 0.2	7.4 ± 0.3	2.6 ± 0.1	7.3 ± 0.5
OK08						
No insect.	3.1 ± 0.5	10.4 ± 0.7	0.0 ± 0.0	6.2 ± 0.4	0.0 ± 0.0	6.2 ± 0.2
Insecticide	5.7 ± 0.3	11.7 ± 1.0	3.1 ± 0.2	8.9 ± 0.6	2.9 ± 0.2	7.4 ± 0.5

TABLE V (Continued)

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/Mg)			
WL318						
No insect.	54 ± 1	62 ± 3	63 ± 2	69 ± 3	54 ± 1	61 ± 3
Insecticide	61 ± 2	67 ± 3	69 ± 2	72 ± 1	61 ± 2	64 ± 2
Arc						
No insect.	49 ± 2	56 ± 1	58 ± 1	69 ± 2	51 ± 3	58 ± 5
Insecticide	59 ± 3	62 ± 1	65 ± 2	68 ± 3	56 ± 3	63 ± 3
OK08						
No insect.	45 ± 1	44 ± 4	48 ± 2	54 ± 2	44 ± 1	50 ± 4
Insecticide	46 ± 3	51 ± 4	50 ± 2	58 ± 1	47 ± 4	50 ± 3
			Gross value ($/ha)			
WL318						
No insect.	873 ± 36 (15.5)[a]	1120 ± 37 (16.0)	1075 ± 67 (16.9)	1163 ± 68 (15.5)	899 ± 55 (15.6)	1036 ± 53 (14.5)
Insecticide	1131 ± 30 (17.0)	1288 ± 109 (16.6)	1187 ± 60 (16.5)	1141 ± 43 (17.8)	1219 ± 74 (18.0)	1315 ± 98 (17.0)
Arc						
No insect.	839 ± 68 (16.3)	927 ± 56 (14.3)	967 ± 59 (16.7)	1212 ± 90 (16.4)	843 ± 106 (15.7)	1042 ± 104 (15.5)
Insecticide	1140 ± 75 (17.9)	1214 ± 28 (16.7)	1208 ± 61 (17.9)	1313 ± 66 (17.5)	1088 ± 62 (17.6)	1258 ± 129 16.7)
OK08						
No insect.	521 ± 75 (10.8)	648 ± 78 (11.8)	616 ± 61 (12.9)	805 ± 66 (13.4)	581 ± 69 (12.6)	746 ± 62 (12.5)
Insecticide	762 ± 98 (14.6)	915 ± 72 (14.8)	811 ± 50 (15.2)	965 ± 36 (14.5)	838 ± 110 (15.8)	1012 ± 87 (16.8)

TABLE V (Continued)

	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/ha)			
WL318						
No insect.	829 ± 35	990 ± 37	1071 ± 67	1077 ± 68	895 ± 55	950 ± 53
Insecticide	1038 ± 30	1108 ± 106	1136 ± 60	1279 ± 43	1168 ± 74	1182 ± 98
Arc						
No insect.	801 ± 65	803 ± 54	967 ± 59	1130 ± 90	842 ± 106	960 ± 104
Insecticide	1054 ± 74	1042 ± 27	1161 ± 61	1184 ± 66	1040 ± 62	1129 ± 129
OK08						
No insect.	488 ± 73	527 ± 75	616 ± 61	723 ± 66	581 ± 69	664 ± 62
Insecticide	680 ± 96	745 ± 69	764 ± 50	837 ± 36	791 ± 110	884 ± 87

	Gross $/Mg	Avg. cost $/Mg	Adj. $/Mg	Gross $/ha	Adj. $/ha
LSD for cultivar=	6	0.9	6	201	160
LSD for harvest management=	6	0.9	6	162	101
LSD for pesticide=	1	0.2	1	37	37

[a] Numbers in parenthesis indicate seasonal total forage production (Mg/ha).

TABLE VI

SEASONAL FORAGE VALUE ($\bar{x}$ ± SE) OF ALFALFA AS INFLUENCED BY HARVEST AND PESTICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1987, SEASON 5

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Gross value ($/Mg)			
WL318						
No insect.	51 ± 1	60 ± 2	49 ± 1	66 ± 4	48 ± 1	62 ± 5
Insecticide	57 ± 2	71 ± 4	55 ± 1	70 ± 4	57 ± 3	67 ± 2
Arc						
No insect.	52 ± 3	57 ± 4	49 ± 2	63 ± 6	48 ± 1	53 ± 5
Insecticide	51 ± 3	66 ± 3	53 ± 2	60 ± 5	51 ± 2	67 ± 3
OK08						
No insect.	45 ± 1	48 ± 2	46 ± 1	49 ± 1	45 ± 1	51 ± 4
Insecticide	47 ± 3	58 ± 8	48 ± 2	54 ± 3	50 ± 3	49 ± 4
			Average cost ($/Mg)			
WL318						
No insect.	0.4 ± 0.1	6.4 ± 0.3	0.3 ± 0.1	6.1 ± 0.6	0.4 ± 0.1	6.5 ± 0.3
Insecticide	3.4 ± 0.2	9.4 ± 0.6	3.3 ± 0.2	8.8 ± 0.6	3.1 ± 0.1	8.6 ± 0.4
Arc						
No insect.	0.0 ± 0.0	7.0 ± 0.2	0.0 ± 0.0	6.1 ± 0.5	0.0 ± 0.0	6.6 ± 0.5
Insecticide	4.2 ± 0.6	9.6 ± 0.7	3.7 ± 0.4	8.8 ± 0.7	3.8 ± 0.2	9.1 ± 0.8
OK08						
No insect.	0.0 ± 0.0	9.8 ± 1.3	0.0 ± 0.0	7.8 ± 0.9	0.0 ± 0.0	9.4 ± 1.3
Insecticide	6.0 ± 1.1	10.9 ± 1.1	5.4 ± 0.5	9.8 ± 1.4	5.4 ± 0.8	12.1 ± 1.6

TABLE VI (Continued)

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/Mg)			
WL318						
No insect.	50 ± 1	54 ± 2	49 ± 1	60 ± 4	47 ± 1	55 ± 6
Insecticide	54 ± 2	61 ± 4	51 ± 2	60 ± 4	54 ± 3	59 ± 2
Arc						
No insect.	52 ± 3	50 ± 4	49 ± 2	57 ± 6	48 ± 1	47 ± 6
Insecticide	47 ± 3	56 ± 3	49 ± 3	51 ± 6	48 ± 2	58 ± 2
OK08						
No insect.	45 ± 1	38 ± 4	46 ± 1	41 ± 2	45 ± 1	41 ± 5
Insecticide	41 ± 4	47 ± 8	43 ± 2	44 ± 4	44 ± 4	37 ± 5
			Gross value ($/ha)			
WL318						
No insect.	550 ± 52 (10.9)[a]	812 ± 65 (13.5)	647 ± 32 (13.1)	971 ± 163 (14.5)	540 ± 62 (11.3)	826 ± 115 (13.2)
Insecticide	870 ± 86 (15.1)	1018 ± 119 (14.3)	844 ± 56 (15.4)	1082 ± 120 (15.4)	949 ± 81 (16.6)	1046 ± 57 (15.6)
Arc						
No insect.	531 ± 101 (10.0)	671 ± 58 (11.8)	548 ± 86 (11.0)	876 ± 149 (13.8)	507 ± 69 (10.5)	678 ± 97 (12.7)
Insecticide	622 ± 107 (12.1)	902 ± 83 (13.7)	710 ± 88 (13.3)	910 ± 126 (15.0)	653 ± 45 (12.7)	969 ± 79 (14.6)
OK08						
No insect.	266 ± 28 (5.9)	433 ± 83 (8.8)	371 ± 56 (8.1)	532 ± 76 (10.8)	335 ± 41 (7.5)	472 ± 86 (9.1)
Insecticide	426 ± 118 (8.7)	718 ± 148 (12.2)	425 ± 45 (8.9)	765 ± 134 (14.0)	467 ± 96 (9.2)	569 ± 126 (11.2)

TABLE VI (Continued)

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/ha)			
WL318						
No insect.	546 ± 52	726 ± 65	642 ± 32	885 ± 163	535 ± 62	740 ± 115
Insecticide	819 ± 86	886 ± 119	793 ± 56	949 ± 120	898 ± 81	913 ± 57
Arc						
No insect.	531 ± 101	589 ± 58	547 ± 86	794 ± 149	507 ± 69	596 ± 97
Insecticide	575 ± 107	773 ± 83	662 ± 88	781 ± 126	605 ± 45	840 ± 79
OK08						
No insect.	266 ± 28	351 ± 83	371 ± 56	451 ± 76	335 ± 41	391 ± 86
Insecticide	379 ± 118	590 ± 148	379 ± 45	636 ± 134	420 ± 96	440 ± 126

	Gross $/Mg	Avg. cost $/Mg	Adj. $/Mg	Gross $/ha	Adj. $/ha
LSD for cultivar=	8	1.8	9	247	247
LSD for harvest management=	7	1.5	7	158	157
LSD for pesticide=	2	0.4	2	38	38

[a] Numbers in parenthesis indicate seasonal total forage production (Mg/ha).

TABLE VII

TOTAL FORAGE VALUE ($\bar{x}$ ± SE) OF ALFALFA AS INFLUENCED BY HARVEST AND PESTICIDE TREATMENTS IN THREE ALFALFA CULTIVARS, CHICKASHA, OKLAHOMA, 1983-1987[a]

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Gross value ($/ha)			
WL318						
No insect.	6282 ± 191 (85.4)[b]	6873 ± 168 (87.4)	6459 ± 233 (86.5)	7034 ± 182 (86.6)	5876 ± 202 (80.2)	6446 ± 124 (80.8)
Insecticide	6975 ± 84 (90.9)	7288 ± 328 (88.6)	6827 ± 151 (88.6)	7698 ± 144 (93.3)	7038 ± 159 (92.7)	7195 ± 180 (89.0)
Arc						
No insect.	6155 ± 293 (87.0)	6631 ± 275 (85.6)	6455 ± 277 (85.9)	7165 ± 488 (89.7)	5966 ± 392 (82.3)	6475 ± 269 (84.3)
Insecticide	6797 ± 307 (90.5)	7214 ± 307 (89.6)	6974 ± 251 (90.3)	7120 ± 258 (89.7)	6513 ± 415 (86.2)	7197 ± 391 (89.3)
OK08						
No insect.	5065 ± 337 (74.3)	5474 ± 222 (74.2)	5384 ± 439 (77.1)	5779 ± 359 (79.4)	4864 ± 285 (70.6)	5583 ± 340 (74.4)
Insecticide	5509 ± 364 (78.5)	6348 ± 262 (84.0)	5894 ± 337 (80.2)	6627 ± 344 (86.3)	5781 ± 323 (80.0)	6078 ± 371 (83.1)
			Average cost ($/ha)			
WL318						
No insect.	216 ± 9	730 ± 30	21 ± 0	429 ± 0	21 ± 0	429 ± 0
Insecticide	512 ± 22	1027 ± 43	256 ± 0	664 ± 0	256 ± 0	664 ± 0
Arc						
No insect.	178 ± 9	652 ± 28	2 ± 0	410 ± 0	2 ± 0	410 ± 0
Insecticide	450 ± 18	923 ± 39	237 ± 0	645 ± 0	237 ± 0	645 ± 0
OK08						
No insect.	173 ± 4	670 ± 5	0 ± 0	408 ± 0	0 ± 0	408 ± 0
Insecticide	458 ± 5	953 ± 2	235 ± 0	643 ± 0	235 ± 0	643 ± 0

TABLE VII (Continued)

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			Adjusted value ($/ha)			
WL318						
No insect.	6102 ± 187	6280 ± 164	6438 ± 233	6605 ± 182	5855 ± 202	6018 ± 124
Insecticide	6557 ± 80	6457 ± 323	6527 ± 151	7035 ± 144	6782 ± 159	6531 ± 180
Arc						
No insect.	5996 ± 293	6059 ± 271	6453 ± 277	6755 ± 488	5964 ± 392	6065 ± 269
Insecticide	6401 ± 307	6406 ± 306	6738 ± 251	6475 ± 258	6276 ± 416	6552 ± 391
OK08						
No insect.	4916 ± 337	4910 ± 221	5384 ± 439	5371 ± 359	4864 ± 285	5176 ± 340
Insecticide	5123 ± 363	5549 ± 262	5659 ± 337	5985 ± 344	5547 ± 323	5436 ± 371

	Gross $/ha	Total cost $/ha	Adj. $/ha
LSD for cultivar=	757	8	756
LSD for harvest management=	583	9	581
LSD for pesticide=	129	1	129

[a] Total value and cost for the 5 yr period.
[b] Numbers in parenthesis indicate total forage production (Mg/ha) 1983-1987.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Alfalfa weevil egg populations were substantially reduced by late fall harvesting or grazing, relative to alfalfa left unharvested through winter, but peak larval numbers were typically reduced only slightly. This was probably due to mortality associated with the first instar larvae from eggs oviposited in fall growth in unharvested subplots. These larvae had greater distances to move to find suitable feeding sites in the terminals of green alfalfa than the larvae from eggs that had been oviposited in green alfalfa stems. There appeared to be potential to delay the occurrence of peak larval population in years when the majority of weevil eggs were laid prior to late harvesting or winter grazing. By delaying the occurrence of peak larval populations, a producer may be able to decrease production costs by reducing the rate of insecticide necessary or the number of applications required to keep the alfalfa weevil below the economic threshold of 1.5-2.0 larvae per stem.

Management of weeds with herbicides throughout the study did not affect the number of alfalfa weevil larvae per stem but did result in an increase in the number/0.1 m^2. Although treatment with herbicides did not successfully control weeds after alfalfa stem density dropped below 20/0.1 m^2, it did result in somewhat greater stem density than the unsprayed treatment and the potential to increase the number of weevil larvae/0.1 m^2.

Root total nonstructural carbohydrates (TNC) and percent dry matter were lower through winter due to late fall harvesting or winter grazing relative to alfalfa left unharvested through winter but were not lower in spring. Feeding damage caused by alfalfa weevil larvae generally reduced root TNC accumulation in spring as compared to plants where the larvae had been controlled. Over the life of an alfalfa stand, continued stress from larval feeding damage would decrease root TNC accumulation in spring, and, along with reductions in plant height, reduce the competitive ability of alfalfa plants and allow more weed encroachment.

Forage production and stand retention of the unimproved cultivar OK08 was comparable to the other cultivars for the first 3 yr of the study but then stands of OK08 degenerated rapidly during the last 2 yr of the study due to high weed infestations in all treatment combinations. Utilization of improved cultivars such as WL318 and Arc were important in maintaining profitable stands of alfalfa relative to OK08.

Compared to alfalfa left unharvested through winter, neither harvesting in late fall nor winter grazing reduced forage production or stand persistence after 5 yr. Though 0.5-1.0 Mg/ha of additional forage was available from harvesting in late fall or grazing in winter, this production was generally insufficient to substantially increase seasonal yield or the annual dollar value of forage produced/ha relative to the unharvested treatment.

Infestations of weeds or alfalfa weevils reduced total alfalfa production by ca. 7.4 Mg/ha over the 5 yr period and ca. 16.9 Mg/ha when both pest types were present. Accelerated stand decline resulted when weeds and weevils were present individually or in combination. Control of weevil larvae resulted in greater alfalfa production and reduced weed infestations by removing stress from alfalfa plants and allowing better competition with weeds. Control of weeds did not always increase the seasonal forage yields but did increase the alfalfa component of the resulting forage. Control of weeds and alfalfa weevils was important in maintaining the production of forage with a higher value than no controls even after costs for insecticide and herbicides were deducted. Management of weeds or alfalfa weevils reduced stand loss relative to unsprayed alfalfa allowing the stand to remain in production for a longer period of time and were of particular importance in the later years of stand life.

APPENDIXES

APPENDIX A

ADDITIONAL HARVEST RESULTS AND STEM DENSITY MEASUREMENTS

TABLE I

MONTHLY RAINFALL DURING FALL HARVEST MANAGEMENT STUDY, CHICKASHA, OKLAHOMA, 1982- 1987

	36 year average 1951-1986	1982	1983	1984	1985	1986	1987
January	2.4	7.0	5.4	0.3	2.0	0.0	5.0
February	3.4	2.0	9.7	3.6	9.8	2.7	9.2
March	5.6	3.3	5.5	5.7	19.7	7.2	4.7
April	7.1	3.0	4.4	4.7	11.9	9.4	0.9
May	13.0	29.1	12.6	3.2	3.2	18.5	24.6
June	8.7	10.1	12.8	16.2	19.6	9.7	14.6
July	5.7	4.1	0.0	0.7	1.6	0.3	-
August	6.3	2.9	5.8	2.6	10.4	6.1	-
September	8.7	6.1	1.8	4.0	10.8	17.9	-
October	8.5	1.6	33.7	15.9	12.2	30.8	-
November	4.4	6.8	1.4	6.7	8.8	13.0	-
December	3.2	4.5	1.6	20.5	0.7	3.0	-
Total	77.0	80.5	94.7	84.1	110.7	118.6	-
Deviation from mean	-	+3.5	+17.7	+7.1	+33.7	+41.6	-

TABLE II

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 12 MAY 1983, SEASON 1

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	4.8 ± 0.2	4.6 ± 0.5	4.7 ± 0.4	4.2 ± 0.2	4.5 ± 0.2	4.7 ± 0.2
Insecticide	5.5 ± 0.4	4.8 ± 0.3	5.0 ± 0.2	4.7 ± 0.2	5.0 ± 0.4	5.0 ± 0.2
Arc						
No insect.	6.0 ± 0.3	5.6 ± 0.5	5.0 ± 0.3	5.0 ± 0.4	5.7 ± 0.2	5.2 ± 0.2
Insecticide	6.0 ± 0.3	5.1 ± 0.2	5.5 ± 0.2	5.4 ± 0.1	5.5 ± 0.3	5.4 ± 0.5
OK08						
No insect.	5.3 ± 0.3	4.2 ± 0.2	4.3 ± 0.2	4.2 ± 0.3	5.0 ± 0.3	4.1 ± 0.1
Insecticide	5.2 ± 0.2	5.3 ± 0.5	4.8 ± 0.1	4.4 ± 0.2	5.9 ± 0.4	4.5 ± 0.3
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	4.5 ± 0.2	4.6 ± 0.5	4.4 ± 0.3	4.2 ± 0.2	4.3 ± 0.2	4.7 ± 0.2
Insecticide	5.4 ± 0.3	4.8 ± 0.3	4.8 ± 0.2	4.7 ± 0.2	4.8 ± 0.4	5.0 ± 0.2
Arc						
No insect.	5.8 ± 0.4	5.6 ± 0.5	4.9 ± 0.3	5.0 ± 0.4	5.5 ± 0.2	5.2 ± 0.2
Insecticide	5.9 ± 0.2	5.1 ± 0.2	5.4 ± 0.1	5.4 ± 0.1	5.4 ± 0.3	5.3 ± 0.5
OK08						
No insect.	5.1 ± 0.3	4.0 ± 0.3	4.0 ± 0.2	4.1 ± 0.2	4.5 ± 0.3	4.1 ± 0.1
Insecticide	5.0 ± 0.2	5.3 ± 0.5	4.7 ± 0.1	4.4 ± 0.2	5.6 ± 0.3	4.5 ± 0.3

TABLE II (Continued)

Cultivar	Fall harvested No herb.	Fall harvested Herbicide	Winter grazed No herb.	Winter grazed Herbicide	Unharvested No herb.	Unharvested Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	4.8 ± 0.5	0.8 ± 0.7	5.3 ± 1.4	0.0 ± 0.0	4.0 ± 1.0	0.0 ± 0.0
Insecticide	2.0 ± 0.9	0.0 ± 0.0	3.5 ± 0.9	0.0 ± 0.0	4.0 ± 1.1	0.0 ± 0.0
Arc						
No insect.	3.0 ± 1.1	0.0 ± 0.0	3.3 ± 0.9	0.0 ± 0.0	2.8 ± 1.1	0.0 ± 0.0
Insecticide	2.5 ± 0.6	0.0 ± 0.0	1.8 ± 0.5	0.0 ± 0.0	2.8 ± 0.6	0.3 ± 0.3
OK08						
No insect.	4.3 ± 0.2	4.0 ± 4.0	6.3 ± 0.9	1.5 ± 1.2	8.8 ± 5.1	0.3 ± 0.3
Insecticide	3.8 ± 1.1	0.3 ± 0.3	1.5 ± 0.6	0.0 ± 0.0	4.5 ± 2.2	0.3 ± 0.3

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.9	0.9	3.8
L.S.D. for harvest management=	0.8	0.8	3.1
L.S.D. for pesticides=	0.2	0.2	0.8

TABLE III

SECOND HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 16 JUNE 1983, SEASON 1

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	4.3 ± 0.2	4.2 ± 0.1	3.9 ± 0.3	4.2 ± 0.3	3.9 ± 0.3	3.9 ± 0.3
Insecticide	4.1 ± 0.3	4.4 ± 0.3	4.0 ± 0.2	4.4 ± 0.1	4.7 ± 0.4	4.8 ± 0.3
Arc						
No insect.	4.2 ± 0.3	4.1 ± 0.3	3.7 ± 0.3	4.5 ± 0.2	3.8 ± 0.3	4.2 ± 0.1
Insecticide	4.8 ± 0.1	4.9 ± 0.3	4.0 ± 0.2	4.1 ± 0.2	4.1 ± 0.4	4.5 ± 0.3
OK08						
No insect.	4.3 ± 0.5	4.1 ± 0.2	3.9 ± 0.3	4.4 ± 0.1	3.8 ± 0.3	4.1 ± 0.2
Insecticide	3.9 ± 0.2	4.2 ± 0.3	4.2 ± 0.1	4.4 ± 0.1	4.5 ± 0.4	4.4 ± 0.2
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	4.3 ± 0.2	4.2 ± 0.1	3.9 ± 0.3	4.2 ± 0.3	3.9 ± 0.3	3.9 ± 0.3
Insecticide	4.0 ± 0.3	4.4 ± 0.3	4.0 ± 0.2	4.4 ± 0.1	4.7 ± 0.4	4.8 ± 0.3
Arc						
No insect.	4.2 ± 0.3	4.1 ± 0.3	3.7 ± 0.3	4.5 ± 0.2	3.8 ± 0.3	4.2 ± 0.1
Insecticide	4.8 ± 0.1	4.9 ± 0.3	4.0 ± 0.2	4.1 ± 0.2	4.1 ± 0.4	4.5 ± 0.3
OK08						
No insect.	4.3 ± 0.5	4.1 ± 0.2	3.8 ± 0.3	4.4 ± 0.1	3.7 ± 0.3	4.1 ± 0.2
Insecticide	3.9 ± 0.2	4.2 ± 0.3	4.2 ± 0.1	4.4 ± 0.1	4.5 ± 0.4	4.4 ± 0.2

	Total	Alfalfa
L.S.D. for cultivar=	0.8	0.8
L.S.D. for harvest management=	0.7	0.7
L.S.D. for pesticides=	0.1	0.2

TABLE IV

THIRD HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 19 JULY 1983, SEASON 1

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	3.6 ± 0.3	3.7 ± 0.2	3.0 ± 0.3	3.4 ± 0.3	3.2 ± 0.2	3.5 ± 0.2
Insecticide	3.1 ± 0.4	3.4 ± 0.3	3.1 ± 0.3	3.3 ± 0.2	3.4 ± 0.3	3.6 ± 0.3
Arc						
No insect.	3.3 ± 0.5	3.1 ± 0.4	3.0 ± 0.4	3.2 ± 0.5	3.3 ± 0.2	3.1 ± 0.1
Insecticide	3.5 ± 0.4	3.2 ± 0.4	3.1 ± 0.6	3.0 ± 0.4	3.3 ± 0.5	3.5 ± 0.5
OK08						
No insect.	3.4 ± 0.2	3.8 ± 0.2	3.2 ± 0.4	3.5 ± 0.2	3.2 ± 0.2	3.1 ± 0.3
Insecticide	3.2 ± 0.4	3.0 ± 0.4	3.4 ± 0.3	3.6 ± 0.4	3.5 ± 0.2	3.1 ± 0.4
			Alfalfa forage yield (Mg/ha)			
WL318						
No insect.	3.6 ± 0.3	3.7 ± 0.2	3.0 ± 0.3	3.4 ± 0.3	3.2 ± 0.2	3.5 ± 0.2
Insecticide	3.1 ± 0.4	3.4 ± 0.3	3.1 ± 0.3	3.3 ± 0.2	3.4 ± 0.3	3.6 ± 0.3
Arc						
No insect.	3.3 ± 0.5	3.1 ± 0.4	3.0 ± 0.4	3.2 ± 0.5	3.3 ± 0.2	3.1 ± 0.1
Insecticide	3.5 ± 0.4	3.2 ± 0.4	3.1 ± 0..6	3.0 ± 0.4	3.3 ± 0.4	3.5 ± 0.5
OK08						
No insect.	3.4 ± 0.2	3.8 ± 0.2	3.2 ± 0.3	3.5 ± 0.2	3.2 ± 0.2	3.1 ± 0.3
Insecticide	3.2 ± 0.4	3.0 ± 0.4	3.4 ± 0.3	3.6 ± 0.4	3.5 ± 0.2	3.1 ± 0.4

	Total	Alfalfa
L.S.D. for cultivar=	0.7	0.7
L.S.D. for harvest management=	0.6	0.6
L.S.D. for pesticides=	0.1	0.1

TABLE V

FOURTH HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 15 SEPTEMBER 1983, SEASON 1

	Fall harvested		Winter grazed		Unharvested	
Cultivar	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.9 ± 0.3	2.6 ± 0.4	2.3 ± 0.3	2.4 ± 0.3	2.3 ± 0.2	2.0 ± 0.4
Insecticide	2.2 ± 0.3	2.2 ± 0.2	2.0 ± 0.1	2.8 ± 0.2	2.1 ± 0.4	2.1 ± 0.4
Arc						
No insect.	2.1 ± 0.5	2.5 ± 0.4	2.2 ± 0.2	2.1 ± 0.2	2.1 ± 0.3	2.0 ± 0.2
Insecticide	2.4 ± 0.3	2.2 ± 0.3	2.2 ± 0.2	1.9 ± 0.1	2.2 ± 0.4	2.2 ± 0.1
OK08						
No insect.	2.6 ± 0.2	2.3 ± 0.4	2.7 ± 0.3	3.2 ± 0.2	2.1 ± 0.2	2.4 ± 0.3
Insecticide	2.2 ± 0.5	2.5 ± 0.5	2.7 ± 0.6	2.6 ± 0.3	2.5 ± 0.4	2.8 ± 0.4

	Total
L.S.D. for cultivar=	0.8
L.S.D. for harvest management=	0.6
L.S.D. for pesticides=	0.1

TABLE VI

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 8 MAY 1984, SEASON 2

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	5.3 ± 0.3	5.3 ± 0.4	5.7 ± 0.4	5.6 ± 0.1	5.6 ± 0.3	5.4 ± 0.1
Insecticide	5.5 ± 0.3	5.2 ± 0.4	5.2 ± 0.4	5.8 ± 0.2	6.1 ± 0.3	5.6 ± 0.4
Arc						
No insect.	6.1 ± 0.2	5.7 ± 0.4	6.1 ± 0.3	6.3 ± 0.8	6.4 ± 0.4	6.0 ± 0.2
Insecticide	5.8 ± 0.3	5.9 ± 0.4	6.0 ± 0.4	6.0 ± 0.2	6.1 ± 0.3	6.0 ± 0.4
OK08						
No insect.	6.3 ± 0.6	4.3 ± 0.2	5.3 ± 0.1	4.9 ± 0.2	5.1 ± 0.1	5.5 ± 0.3
Insecticide	4.7 ± 0.1	5.1 ± 0.3	5.2 ± 0.2	5.2 ± 0.2	5.5 ± 0.2	5.1 ± 0.1
			Alfalfa forage yield (Mg/ha)			
WL318						
No insect.	5.2 ± 0.3	5.3 ± 0.4	5.6 ± 0.4	5.6 ± 0.1	5.5 ± 0.4	5.4 ± 0.1
Insecticide	5.5 ± 0.3	5.2 ± 0.4	5.1 ± 0.4	5.8 ± 0.2	6.0 ± 0.3	5.5 ± 0.3
Arc						
No insect.	5.9 ± 0.3	5.7 ± 0.4	6.1 ± 0.3	6.3 ± 0.8	6.2 ± 0.3	6.0 ± 0.2
Insecticide	5.8 ± 0.3	5.9 ± 0.4	6.0 ± 0.4	6.0 ± 0.2	6.1 ± 0.3	6.0 ± 0.4
OK08						
No insect.	6.1 ± 0.6	4.3 ± 0.2	5.1 ± 0.1	4.9 ± 0.2	4.8 ± 0.1	5.5 ± 0.3
Insecticide	4.6 ± 0.1	5.1 ± 0.3	5.2 ± 0.2	5.2 ± 0.2	5.4 ± 0.2	5.1 ± 0.1

TABLE VI (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	2.3 ± 1.1	0.8 ± 0.7	0.3 ± 0.3	0.0 ± 0.0	2.0 ± 1.7	0.8 ± 0.7
Insecticide	1.5 ± 1.2	0.0 ± 0.0	1.0 ± 0.7	0.0 ± 0.0	1.5 ± 1.2	1.3 ± 1.2
Arc						
No insect.	3.5 ± 1.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	1.8 ± 0.7	0.0 ± 0.0
Insecticide	0.8 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0
OK08						
No insect.	3.0 ± 0.8	0.0 ± 0.0	2.8 ± 1.3	0.0 ± 0.0	4.3 ± 2.0	0.0 ± 0.0
Insecticide	2.5 ± 1.0	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	1.3 ± 0.6	0.0 ± 0.0

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.2	1.2	2.1
L.S.D. for harvest management=	1.0	1.0	1.8
L.S.D. for pesticides=	0.2	0.2	0.2

TABLE VII

SECOND HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 18 JUNE 1984, SEASON 2

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	6.0 ± 0.6	6.3 ± 0.1	6.0 ± 0.3	6.2 ± 0.6	5.6 ± 0.6	5.9 ± 0.3
Insecticide	6.1 ± 0.3	6.1 ± 0.4	6.1 ± 0.3	6.3 ± 0.4	6.0 ± 0.3	6.1 ± 0.3
Arc						
No insect.	6.6 ± 0.1	6.4 ± 0.7	7.6 ± 1.7	6.6 ± 0.4	6.1 ± 0.2	6.8 ± 0.5
Insecticide	6.4 ± 0.1	6.6 ± 0.4	6.0 ± 0.1	6.2 ± 0.3	6.6 ± 0.3	6.3 ± 0.2
OK08						
No insect.	6.4 ± 1.4	5.7 ± 0.1	7.1 ± 1.6	5.9 ± 0.3	5.4 ± 0.5	5.9 ± 0.3
Insecticide	6.8 ± 0.6	6.3 ± 0.1	5.8 ± 0.4	5.9 ± 0.4	5.9 ± 0.1	7.5 ± 1.4

	Total
L.S.D. for cultivar=	1.8
L.S.D. for harvest management=	1.9
L.S.D. for pesticides=	0.4

TABLE VIII

THIRD HARVEST YIELD OF ALFALFA FORAGE ($\bar{x} \pm$ SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 19 JULY 1984, SEASON 2

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	3.8 ± 0.2	3.8 ± 0.3	3.7 ± 0.5	3.4 ± 0.3	3.6 ± 0.4	3.3 ± 0.6
Insecticide	4.3 ± 0.4	4.1 ± 0.4	2.7 ± 0.3	3.9 ± 0.3	4.2 ± 0.4	3.7 ± 0.3
Arc						
No insect.	3.6 ± 0.2	3.8 ± 0.5	3.1 ± 0.2	3.5 ± 0.5	3.3 ± 0.2	3.2 ± 0.1
Insecticide	3.5 ± 0.2	3.1 ± 0.4	3.3 ± 0.4	2.9 ± 0.2	2.7 ± 0.6	3.8 ± 0.4
OK08						
No insect.	3.5 ± 0.4	3.8 ± 0.4	3.0 ± 0.3	3.7 ± 0.4	3.0 ± 0.3	3.5 ± 0.4
Insecticide	3.6 ± 0.5	3.5 ± 0.5	3.4 ± 0.4	3.7 ± 0.3	3.5 ± 0.3	3.5 ± 0.5

	Total
L.S.D. for cultivar=	1.0
L.S.D. for harvest management=	0.9
L.S.D. for pesticides=	0.2

TABLE IX

FOURTH HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 6 SEPTEMBER 1984, SEASON 2

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	3.7 ± 0.5	3.5 ± 0.2	3.4 ± 0.2	3.6 ± 0.3	3.7 ± 0.3	2.8 ± 0.2
Insecticide	3.6 ± 0.2	3.4 ± 0.2	2.9 ± 0.5	4.0 ± 0.2	3.7 ± 0.3	3.3 ± 0.1
Arc						
No insect.	3.6 ± 0.1	3.7 ± 0.5	3.1 ± 0.2	3.0 ± 0.2	3.4 ± 0.2	3.3 ± 0.4
Insecticide	3.5 ± 0.4	3.3 ± 0.4	3.2 ± 0.3	3.1 ± 0.2	3.5 ± 0.5	3.6 ± 0.4
OK08						
No insect.	3.2 ± 0.6	2.8 ± 0.3	2.6 ± 0.3	3.5 ± 0.3	3.0 ± 0.2	3.2 ± 0.3
Insecticide	3.5 ± 0.4	3.6 ± 0.3	3.1 ± 0.5	3.3 ± 0.3	3.1 ± 0.3	3.4 ± 0.4
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	3.7 ± 0.5	3.5 ± 0.2	3.4 ± 0.2	3.6 ± 0.3	3.7 ± 0.3	2.8 ± 0.2
Insecticide	3.6 ± 0.2	3.4 ± 0.2	2.9 ± 0.5	4.0 ± 0.2	3.7 ± 0.3	3.3 ± 0.1
Arc						
No insect.	3.3 ± 0.2	3.7 ± 0.5	3.1 ± 0.2	3.0 ± 0.2	3.4 ± 0.2	3.3 ± 0.4
Insecticide	3.5 ± 0.4	3.3 ± 0.4	3.2 ± 0.3	3.1 ± 0.2	3.5 ± 0.5	3.6 ± 0.4
OK08						
No insect.	2.8 ± 0.6	2.8 ± 0.3	2.6 ± 0.3	3.5 ± 0.3	2.8 ± 0.3	3.2 ± 0.3
Insecticide	3.2 ± 0.2	3.6 ± 0.3	3.1 ± 0.5	3.3 ± 0.3	3.1 ± 0.3	3.4 ± 0.4

TABLE IX (Continued)

Cultivar	Fall harvested No herb.	Fall harvested Herbicide	Winter grazed No herb.	Winter grazed Herbicide	Unharvested No herb.	Unharvested Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Insecticide	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Arc						
No insect.	7.5 ± 7.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Insecticide	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
OK08						
No insect.	12.5 ± 7.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	7.5 ± 7.5	0.0 ± 0.0
Insecticide	6.3 ± 6.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.9	0.9	6.6
L.S.D. for harvest management=	0.9	0.9	6.6
L.S.D. for pesticides=	0.2	0.2	1.5

TABLE X

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x} \pm$ SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 3 MAY 1985, SEASON 3

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	5.2 ± 0.4	5.0 ± 0.4	5.3 ± 0.4	5.3 ± 0.2	5.2 ± 0.1	5.7 ± 0.4
Insecticide	5.8 ± 0.1	5.6 ± 0.2	6.0 ± 0.5	6.0 ± 0.1	6.3 ± 0.6	5.6 ± 0.2
Arc						
No insect.	6.8 ± 0.3	6.4 ± 0.2	6.6 ± 0.4	6.4 ± 0.3	6.0 ± 0.2	6.2 ± 0.2
Insecticide	6.2 ± 0.1	6.4 ± 0.6	6.8 ± 0.7	6.4 ± 0.2	5.8 ± 0.5	7.0 ± 0.3
OK08						
No insect.	5.0 ± 0.3	4.6 ± 0.2	4.7 ± 0.3	4.7 ± 0.4	4.4 ± 0.5	5.2 ± 0.5
Insecticide	4.8 ± 0.3	5.8 ± 0.5	5.2 ± 0.4	5.9 ± 0.4	5.0 ± 0.7	5.6 ± 0.5
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	4.8 ± 0.6	4.9 ± 0.4	4.8 ± 0.8	5.3 ± 0.2	4.9 ± 0.1	5.6 ± 0.4
Insecticide	5.7 ± 0.1	5.6 ± 0.2	5.9 ± 0.5	5.9 ± 0.1	5.9 ± 0.5	5.5 ± 0.2
Arc						
No insect.	5.5 ± 0.8	6.3 ± 0.2	6.5 ± 0.4	5.8 ± 0.8	5.1 ± 0.9	5.5 ± 0.5
Insecticide	5.3 ± 0.7	6.3 ± 0.6	6.7 ± 0.7	6.3 ± 0.2	5.8 ± 0.5	6.9 ± 0.2
OK08						
No insect.	3.1 ± 0.9	4.2 ± 0.3	3.9 ± 0.7	4.4 ± 0.5	3.9 ± 0.4	4.7 ± 0.6
Insecticide	4.0 ± 0.6	5.5 ± 0.5	4.6 ± 0.9	5.6 ± 0.5	4.5 ± 1.0	5.0 ± 0.9

TABLE X (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	10.3 ± 5.2	2.0 ± 1.1	10.8 ± 9.7	0.8 ± 0.3	4.8 ± 1.4	1.0 ± 0.4
Insecticide	1.8 ± 1.1	1.5 ± 0.6	1.3 ± 0.2	1.5 ± 0.5	6.8 ± 3.5	2.5 ± 0.9
Arc						
No insect.	17.8 ±11.1	1.3 ± 0.3	1.3 ± 0.6	10.8 ± 9.8	15.8 ±14.8	11.5 ± 9.5
Insecticide	15.3 ±11.8	1.3 ± 0.6	0.8 ± 0.5	1.0 ± 0.0	1.0 ± 0.7	2.0 ± 0.4
OK08						
No insect.	38.3 ±13.7	8.8 ± 3.6	19.3 ±16.9	6.8 ± 4.5	14.8 ± 6.5	11.8 ± 4.7
Insecticide	15.3 ±11.8	5.5 ± 3.3	14.0 ±12.0	5.5 ± 3.3	13.3 ±12.3	13.5 ± 9.0

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.1	1.5	19.5
L.S.D. for harvest management=	0.9	1.2	15.6
L.S.D. for pesticides=	0.2	0.2	3.6

TABLE XI

SECOND HARVEST YIELD OF ALFALFA FORAGE ($\bar{x} \pm SE$) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 14 JUNE 1985, SEASON 3

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	5.6 ± 0.2	5.0 ± 0.2	5.2 ± 0.1	5.2 ± 0.2	5.0 ± 0.3	4.7 ± 0.3
Insecticide	5.5 ± 0.2	5.3 ± 0.2	5.3 ± 0.2	5.0 ± 0.1	5.4 ± 0.3	5.7 ± 0.2
Arc						
No insect.	5.5 ± 0.1	5.3 ± 0.4	5.5 ± 0.3	5.6 ± 0.3	5.1 ± 0.6	5.4 ± 0.2
Insecticide	5.2 ± 0.2	5.4 ± 0.3	5.5 ± 0.6	5.1 ± 0.5	5.2 ± 0.1	5.5 ± 0.5
OK08						
No insect.	4.6 ± 0.4	5.1 ± 0.4	6.2 ± 1.3	4.4 ± 0.2	4.9 ± 0.4	5.4 ± 0.3
Insecticide	4.7 ± 0.3	4.9 ± 0.3	4.7 ± 0.3	5.6 ± 0.5	5.0 ± 0.3	4.8 ± 0.4
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	5.6 ± 0.2	4.9 ± 0.2	5.2 ± 0.1	5.2 ± 0.2	5.0 ± 0.3	4.7 ± 0.3
Insecticide	5.5 ± 0.2	5.3 ± 0.2	5.3 ± 0.2	5.0 ± 0.1	5.3 ± 0.3	5.7 ± 0.2
Arc						
No insect.	5.5 ± 0.1	5.3 ± 0.4	5.5 ± 0.3	5.6 ± 0.3	5.1 ± 0.6	5.4 ± 0.2
Insecticide	5.2 ± 0.2	5.4 ± 0.3	5.5 ± 0.6	5.1 ± 0.5	5.2 ± 0.1	5.5 ± 0.5
OK08						
No insect.	4.5 ± 0.4	5.1 ± 0.4	6.1 ± 1.3	4.3 ± 0.1	4.8 ± 0.4	5.4 ± 0.3
Insecticide	4.6 ± 0.4	4.9 ± 0.3	4.7 ± 0.3	5.6 ± 0.5	5.0 ± 0.3	4.8 ± 0.5

TABLE XI (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	0.3 ± 0.3	0.3 ± 0.3	0.8 ± 0.3	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
Insecticide	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.3	0.3 ± 0.3	0.3 ± 0.3
Arc						
No insect.	0.5 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.3	0.5 ± 0.3	0.3 ± 0.3
Insecticide	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
OK08						
No insect.	2.8 ± 1.3	0.3 ± 0.3	0.8 ± 0.3	3.0 ± 2.3	0.8 ± 0.3	0.5 ± 0.3
Insecticide	2.8 ± 2.4	0.5 ± 0.3	0.5 ± 0.3	0.0 ± 0.0	0.3 ± 0.3	1.5 ± 1.2

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.1	1.1	1.9
L.S.D. for harvest management=	1.0	1.0	1.9
L.S.D. for pesticides=	0.2	0.2	0.5

TABLE XII

THIRD HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 12 JULY 1985, SEASON 3

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	4.6 ± 0.1	4.8 ± 0.4	4.6 ± 0.1	4.8 ± 0.4	4.6 ± 0.3	4.6 ± 0.5
Insecticide	4.7 ± 0.4	4.6 ± 0.3	5.2 ± 0.3	4.8 ± 0.2	5.1 ± 0.2	5.0 ± 0.2
Arc						
No insect.	4.1 ± 0.3	4.6 ± 0.4	4.1 ± 0.4	4.3 ± 0.4	4.6 ± 0.4	4.3 ± 0.5
Insecticide	4.0 ± 0.5	4.4 ± 0.5	4.5 ± 0.6	4.0 ± 0.3	4.1 ± 0.4	4.3 ± 0.4
OK08						
No insect.	4.5 ± 0.3	3.8 ± 0.5	4.6 ± 0.3	3.8 ± 0.4	4.0 ± 0.4	4.2 ± 0.4
Insecticide	3.5 ± 0.5	3.9 ± 0.3	4.3 ± 0.3	4.2 ± 0.3	4.7 ± 0.6	4.1 ± 0.7
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	4.5 ± 0.1	4.8 ± 0.4	4.5 ± 0.1	4.8 ± 0.4	4.6 ± 0.3	4.6 ± 0.5
Insecticide	4.7 ± 0.4	4.6 ± 0.3	5.2 ± 0.3	4.8 ± 0.2	5.1 ± 0.2	5.0 ± 0.2
Arc						
No insect.	3.9 ± 0.5	4.5 ± 0.5	4.1 ± 0.4	4.3 ± 0.4	4.6 ± 0.4	4.3 ± 0.6
Insecticide	4.0 ± 0.5	4.4 ± 0.5	4.5 ± 0.6	4.0 ± 0.3	4.1 ± 0.4	4.3 ± 0.4
OK08						
No insect.	3.3 ± 0.7	3.7 ± 0.5	4.2 ± 0.4	2.7 ± 0.8	3.6 ± 0.4	4.1 ± 0.4
Insecticide	2.8 ± 0.8	3.7 ± 0.4	4.0 ± 0.4	4.2 ± 0.3	4.4 ± 0.4	3.5 ± 0.9

TABLE XII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	0.3 ± 0.3	0.5 ± 0.3	0.3 ± 0.3	0.3 ± 0.3	0.3 ± 0.3	0.0 ± 0.0
Insecticide	0.3 ± 0.3	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.3
Arc						
No insect.	5.8 ± 4.8	2.5 ± 1.4	0.3 ± 0.3	0.3 ± 0.3	1.5 ± 1.2	1.0 ± 0.7
Insecticide	1.3 ± 0.7	1.3 ± 0.6	0.3 ± 0.3	0.8 ± 0.6	0.0 ± 0.0	0.0 ± 0.0
OK08						
No insect.	30.3 ±12.0	5.0 ± 2.0	6.3 ± 2.4	31.5 ±16.5	8.3 ± 4.4	1.5 ± 1.2
Insecticide	22.8 ±16.4	5.0 ± 3.5	8.0 ± 7.3	1.3 ± 1.2	5.3 ± 3.4	15.0 ±11.7

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	1.1	14.8
L.S.D. for harvest management=	0.7	0.9	12.5
L.S.D. for pesticides=	0.2	0.2	3.1

TABLE XIII

FOURTH HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 15 AUGUST 1985, SEASON 3

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	3.7 ± 0.3	3.7 ± 0.2	3.3 ± 0.2	3.2 ± 0.5	3.9 ± 0.3	3.8 ± 0.3
Insecticide	3.3 ± 0.3	3.3 ± 0.2	3.4 ± 0.3	3.8 ± 0.2	3.4 ± 0.2	3.7 ± 0.3
Arc						
No insect.	3.6 ± 0.2	3.4 ± 0.4	3.2 ± 0.3	3.6 ± 0.4	3.6 ± 0.4	3.4 ± 0.4
Insecticide	3.7 ± 0.3	3.3 ± 0.5	3.3 ± 0.4	3.8 ± 0.3	3.8 ± 0.2	3.4 ± 0.2
OK08						
No insect.	3.9 ± 0.3	4.1 ± 0.2	3.7 ± 0.4	3.7 ± 0.3	3.8 ± 0.3	3.7 ± 0.4
Insecticide	3.7 ± 0.1	3.8 ± 0.2	3.6 ± 0.3	3.6 ± 0.6	3.4 ± 0.3	3.5 ± 0.2
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	3.5 ± 0.3	3.7 ± 0.1	3.3 ± 0.2	3.2 ± 0.5	3.9 ± 0.2	3.7 ± 0.3
Insecticide	3.3 ± 0.3	3.2 ± 0.2	3.4 ± 0.3	3.8 ± 0.2	3.4 ± 0.1	3.7 ± 0.2
Arc						
No insect.	3.0 ± 0.5	3.2 ± 0.4	3.2 ± 0.3	3.5 ± 0.4	3.4 ± 0.5	3.3 ± 0.4
Insecticide	3.5 ± 0.4	3.2 ± 0.5	3.3 ± 0.4	3.7 ± 0.3	3.7 ± 0.2	3.4 ± 0.2
OK08						
No insect.	2.2 ± 0.4	3.3 ± 0.3	3.1 ± 0.6	3.2 ± 0.4	3.2 ± 0.2	3.5 ± 0.5
Insecticide	2.4 ± 0.8	3.3 ± 0.3	3.5 ± 0.3	3.5 ± 0.6	3.1 ± 0.2	2.9 ± 0.5

TABLE XIII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	4.3 ± 3.6	1.5 ± 1.2	0.3 ± 0.3	1.0 ± 0.7	1.0 ± 0.7	2.0 ± 1.7
Insecticide	2.0 ± 1.7	2.0 ± 1.7	0.3 ± 0.3	0.3 ± 0.3	0.3 ± 0.3	0.8 ± 0.7
Arc						
No insect.	17.5 ±11.3	5.8 ± 2.5	1.5 ± 1.2	1.8 ± 1.2	6.8 ± 6.1	3.3 ± 2.3
Insecticide	7.5 ± 4.8	2.8 ± 2.4	2.0 ± 1.2	2.0 ± 1.1	1.8 ± 0.7	2.0 ± 1.7
OK08						
No insect.	40.8 ±14.2	16.8 ± 9.2	18.0 ±10.0	12.8 ± 6.5	13.0 ± 7.2	6.5 ± 3.6
Insecticide	35.8 ±19.8	12.0 ± 9.5	2.8 ± 1.0	3.0 ± 1.8	8.8 ± 3.2	19.5 ± 9.3

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	1.0	16.5
L.S.D. for harvest management=	0.8	0.8	14.7
L.S.D. for pesticides=	0.2	0.2	2.6

TABLE XIV

FIFTH HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 13 SEPTEMBER 1985, SEASON 3

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.9 ± 0.1	2.7 ± 0.2	2.8 ± 0.3	2.2 ± 0.3	2.4 ± 0.5	2.8 ± 0.7
Insecticide	2.3 ± 0.5	2.4 ± 0.4	2.8 ± 0.2	2.6 ± 0.3	2.7 ± 0.1	2.4 ± 0.3
Arc						
No insect.	2.4 ± 0.3	2.2 ± 0.4	2.2 ± 0.2	2.6 ± 0.4	2.5 ± 0.5	2.9 ± 0.2
Insecticide	2.8 ± 0.4	2.5 ± 0.4	2.9 ± 0.4	2.6 ± 0.2	2.8 ± 0.2	2.7 ± 0.2
OK08						
No insect.	2.1 ± 0.2	2.4 ± 0.2	2.4 ± 0.3	2.6 ± 0.3	2.8 ± 0.4	2.6 ± 0.1
Insecticide	2.7 ± 0.1	2.5 ± 0.2	3.2 ± 0.4	2.9 ± 0.3	2.5 ± 0.1	2.9 ± 0.4
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	2.9 ± 0.1	2.7 ± 0.2	2.8 ± 0.3	2.2 ± 0.3	2.4 ± 0.5	2.8 ± 0.7
Insecticide	2.3 ± 0.5	2.4 ± 0.4	2.8 ± 0.2	2.6 ± 0.3	2.7 ± 0.1	2.4 ± 0.3
Arc						
No insect.	2.0 ± 0.4	2.0 ± 0.3	2.2 ± 0.2	2.6 ± 0.5	2.3 ± 0.6	2.8 ± 0.3
Insecticide	2.6 ± 0.4	2.4 ± 0.4	2.8 ± 0.4	2.5 ± 0.3	2.8 ± 0.2	2.6 ± 0.2
OK08						
No insect.	1.2 ± 0.5	2.1 ± 0.1	2.0 ± 0.3	2.4 ± 0.3	2.3 ± 0.6	2.4 ± 0.2
Insecticide	1.9 ± 0.5	2.0 ± 0.3	3.1 ± 0.4	2.9 ± 0.3	2.3 ± 0.2	2.4 ± 0.6

TABLE XIV (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	1.0 ± 0.7	0.8 ± 0.5	1.5 ± 0.5	1.3 ± 0.5	0.5 ± 0.3	1.5 ± 1.2
Insecticide	1.5 ± 0.6	1.8 ± 1.0	1.0 ± 0.4	0.5 ± 0.3	0.8 ± 0.5	0.3 ± 0.3
Arc						
No insect.	15.5 ±11.7	8.5 ± 5.7	3.0 ± 1.4	2.5 ± 1.4	9.5 ± 8.5	3.3 ± 2.3
Insecticide	5.8 ± 4.8	5.3 ± 4.9	2.3 ± 1.1	5.8 ± 4.8	1.3 ± 0.5	3.3 ± 1.7
OK08						
No insect.	43.0 ±21.4	12.5 ± 7.5	16.5 ± 9.7	8.5 ± 3.8	20.3 ±10.6	6.8 ± 2.8
Insecticide	30.5 ±17.5	15.5 ±11.6	3.8 ± 2.2	2.8 ± 1.5	9.5 ± 4.1	21.3 ± 8.7

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	1.0	17.0
L.S.D. for harvest management=	0.7	0.9	15.4
L.S.D. for pesticides=	0.1	0.2	2.9

TABLE XV

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 29 APRIL 1986, SEASON 4

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.7 ± 0.1	2.5 ± 0.1	3.1 ± 0.2	2.7 ± 0.3	3.1 ± 0.1	2.7 ± 0.2
Insecticide	4.1 ± 0.1	3.8 ± 0.3	4.2 ± 0.2	4.2 ± 0.1	4.8 ± 0.6	4.3 ± 0.2
Arc						
No insect.	3.2 ± 0.2	2.5 ± 0.1	3.2 ± 0.3	3.0 ± .2	3.6 ± 0.4	3.2 ± 0.1
Insecticide	4.7 ± 0.3	4.0 ± 0.2	4.6 ± 0.3	4.2 ± 0.2	4.8 ± 0.3	4.4 ± 0.2
OK08						
No insect.	2.0 ± 0.2	1.9 ± 0.5	2.2 ± 0.3	2.2 ± 0.6	3.0 ± 0.8	1.7 ± 0.5
Insecticide	3.0 ± 0.4	2.9 ± 0.1	3.5 ± 0.1	3.3 ± 0.4	3.8 ± 0.2	3.4 ± 0.3
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	1.4 ± 0.2	2.2 ± 0.1	1.9 ± 0.2	2.6 ± 0.2	1.4 ± 0.3	2.6 ± 0.2
Insecticide	2.9 ± 0.5	3.7 ± 0.3	3.6 ± 0.2	4.1 ± 0.1	3.6 ± 0.7	4.0 ± 0.3
Arc						
No insect.	1.1 ± 0.3	2.1 ± 0.1	2.1 ± 0.4	2.8 ± 0.2	1.4 ± 0.4	2.9 ± 0.2
Insecticide	3.8 ± 0.4	3.8 ± 0.2	4.1 ± 0.4	4.1 ± 0.2	3.4 ± 0.5	4.3 ± 0.2
OK08						
No insect.	0.4 ± 0.2	1.4 ± 0.4	0.4 ± 0.1	1.8 ± 0.4	0.3 ± 0.1	1.5 ± 0.3
Insecticide	1.4 ± 0.5	2.5 ± 0.2	2.2 ± 0.3	3.0 ± 0.2	1.9 ± 0.6	2.9 ± 0.4

TABLE XV (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	48.5 ± 5.7	8.8 ± 3.5	38.0 ± 5.6	3.5 ± 1.7	52.8 ±11.7	5.3 ± 1.9
Insecticide	28.0 ±12.5	2.8 ± 1.1	13.0 ± 3.7	2.3 ± 0.9	27.8 ± 4.9	8.0 ± 4.7
Arc						
No insect.	66.3 ± 8.5	14.5 ± 3.7	34.3 ± 8.6	7.5 ± 3.2	60.0 ± 7.9	10.5 ± 5.4
Insecticide	20.0 ± 4.4	4.8 ± 0.9	11.5 ± 4.9	3.8 ± 1.4	28.8 ± 7.6	2.5 ± 1.0
OK08						
No insect.	80.5 ±11.9	25.0 ±10.1	81.3 ± 6.3	16.3 ± 5.1	88.8 ± 4.7	8.5 ± 4.6
Insecticide	52.8 ±11.9	12.5 ± 3.8	38.0 ± 8.8	8.5 ± 3.4	52.0 ±13.1	14.5 ± 4.8

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.6	0.9	20.2
L.S.D. for harvest management=	1.2	0.8	17.0
L.S.D. for pesticides=	0.2	0.2	3.7

TABLE XVI

SECOND HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 10 JUNE 1986, SEASON 4

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	3.9 ± 0.4	3.9 ± 0.1	4.7 ± 0.2	4.0 ± 0.3	3.9 ± 0.3	3.8 ± 0.2
Insecticide	4.3 ± 0.1	4.3 ± 0.3	4.3 ± 0.2	4.7 ± 0.2	4.6 ± 0.2	4.3 ± 0.2
Arc						
No insect.	4.1 ± 0.3	4.1 ± 0.3	4.3 ± 0.2	4.7 ± 0.2	4.2 ± 0.3	4.0 ± 0.2
Insecticide	4.4 ± 0.3	4.4 ± 0.4	4.5 ± 0.1	4.3 ± 0.1	4.3 ± 0.1	4.3 ± 0.2
OK08						
No insect.	2.6 ± 0.4	2.9 ± 0.2	3.6 ± 0.2	3.3 ± 0.3	2.9 ± 0.3	3.2 ± 0.2
Insecticide	3.4 ± 0.3	4.0 ± 0.3	3.9 ± 0.3	3.6 ± 0.2	3.9 ± 0.4	4.1 ± 0.2
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	3.0 ± 0.3	3.7 ± 0.1	4.1 ± 0.4	3.9 ± 0.3	3.2 ± 0.2	3.6 ± 0.3
Insecticide	4.2 ± 0.1	4.3 ± 0.3	4.2 ± 0.2	4.6 ± 0.2	4.5 ± 0.2	4.2 ± 0.3
Arc						
No insect.	2.9 ± 0.3	3.7 ± 0.2	3.7 ± 0.2	4.6 ± 0.2	3.1 ± 0.6	3.8 ± 0.2
Insecticide	4.1 ± 0.4	4.3 ± 0.4	4.4 ± 0.2	4.3 ± 0.2	4.2 ± 0.1	4.2 ± 0.2
OK08						
No insect.	0.8 ± 0.5	2.0 ± 0.6	1.8 ± 0.2	2.6 ± 0.3	1.3 ± 0.3	2.5 ± 0.4
Insecticide	2.2 ± 0.6	3.5 ± 0.3	3.2 ± 0.3	3.1 ± 0.1	3.0 ± 0.6	3.8 ± 0.2

TABLE XVI (Continued)

Cultivar	Fall harvested No herb.	Fall harvested Herbicide	Winter grazed No herb.	Winter grazed Herbicide	Unharvested No herb.	Unharvested Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	21.5 ± 2.1	6.5 ± 1.9	13.3 ± 5.1	3.5 ± 0.9	19.3 ± 2.8	5.3 ± 2.5
Insecticide	2.3 ± 0.2	1.3 ± 0.5	2.8 ± 0.9	2.0 ± 0.7	3.8 ± 1.0	2.5 ± 0.9
Arc						
No insect.	29.0 ± 5.7	8.8 ± 2.8	14.3 ± 2.8	3.0 ± 0.6	28.0 ±10.9	6.3 ± 2.3
Insecticide	6.3 ± 3.3	2.3 ± 0.2	3.3 ± 0.2	1.8 ± 1.1	3.8 ± 0.6	2.0 ± 0.4
OK08						
No insect.	75.8 ±12.3	34.5 ±16.2	50.0 ± 5.9	22.3 ± 2.8	56.8 ± 6.8	22.3 ± 8.1
Insecticide	39.0 ±10.7	12.0 ± 5.2	19.3 ± 6.3	11.0 ± 4.4	24.5 ± 7.7	7.8 ± 3.0

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.7	0.9	15.3
L.S.D. for harvest management=	0.7	0.8	5.8
L.S.D. for pesticides=	0.2	0.2	3.2

TABLE XVII

THIRD HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 10 JULY 1986, SEASON 4

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.4 ± 0.2	2.8 ± 0.2	2.8 ± 0.2	2.5 ± 0.2	2.5 ± 0.3	2.5 ± 0.1
Insecticide	2.8 ± 0.1	2.8 ± 0.2	2.6 ± 0.1	3.2 ± 0.2	3.2 ± 0.3	3.0 ± 0.2
Arc						
No insect.	2.7 ± 0.4	2.3 ± 0.2	2.5 ± 0.3	2.8 ± 0.5	2.3 ± 0.3	2.4 ± 0.4
Insecticide	2.7 ± 0.3	2.7 ± 0.3	2.3 ± 0.4	2.5 ± 0.3	3.0 ± 0.2	3.0 ± 0.6
OK08						
No insect.	1.5 ± 0.4	1.7 ± 0.1	1.8 ± 0.2	2.1 ± 0.2	2.1 ± 0.3	2.2 ± 0.2
Insecticide	2.1 ± 0.2	2.5 ± 0.2	1.9 ± 0.2	2.4 ± 0.4	2.7 ± 0.2	2.5 ± 0.1
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	2.1 ± 0.1	2.7 ± 0.2	2.7 ± 0.2	2.5 ± 0.3	2.3 ± 0.2	2.5 ± 0.1
Insecticide	2.7 ± 0.1	2.7 ± 0.2	2.6 ± 0.1	3.2 ± 0.2	3.1 ± 0.3	3.0 ± 0.2
Arc						
No insect.	1.9 ± 0.6	2.2 ± 0.2	2.1 ± 0.3	2.8 ± 0.5	1.7 ± 0.6	2.3 ± 0.4
Insecticide	2.5 ± 0.3	2.7 ± 0.3	2.2 ± 0.3	2.4 ± 0.2	2.8 ± 0.3	3.0 ± 0.6
OK08						
No insect.	0.8 ± 0.4	0.8 ± 0.4	0.6 ± 0.2	1.7 ± 0.3	0.7 ± 0.3	1.8 ± 0.2
Insecticide	1.5 ± 0.5	1.8 ± 0.6	0.2 ± 0.3	2.2 ± 0.3	0.5 ± 0.4	2.1 ± 0.2

TABLE XVII (Continued)

Cultivar	Fall harvested No herb.	Fall harvested Herbicide	Winter grazed No herb.	Winter grazed Herbicide	Unharvested No herb.	Unharvested Herbicide
			Percentage of weed in forage			
WL318						
No insect.	10.5 ± 2.2	2.5 ± 0.5	3.5 ± 2.5	2.8 ± 2.4	10.0 ± 3.2	1.3 ± 0.8
Insecticide	3.3 ± 0.9	0.8 ± 0.5	0.8 ± 0.3	1.3 ± 0.7	1.3 ± 0.5	0.0 ± 0.0
Arc						
No insect.	33.5 ±15.4	3.8 ± 0.5	14.8 ± 3.1	1.3 ± 0.2	27.8 ±19.0	6.5 ± 3.2
Insecticide	6.3 ± 2.5	0.3 ± 0.3	3.8 ± 2.2	1.5 ± 0.6	9.0 ± 4.5	0.5 ± 0.3
OK08						
No insect.	57.3 ±21.0	56.0 ±19.6	66.8 ±16.7	19.8 ± 7.9	68.5 ±11.8	17.5 ± 7.6
Insecticide	34.8 ±18.4	31.0 ±21.6	39.8 ±13.9	7.8 ± 1.7	35.5 ±16.4	14.0 ± 5.2

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	1.0	29.9
L.S.D. for harvest management=	0.6	0.7	22.3
L.S.D. for pesticides=	0.1	0.2	5.8

TABLE XVIII

FOURTH HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 8 AUGUST 1986, SEASON 4

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.1 ± 0.1	2.5 ± 0.2	1.8 ± 0.4	1.6 ± 0.2	2.6 ± 0.6	2.2 ± 0.2
Insecticide	2.0 ± 0.3	1.7 ± 0.3	1.3 ± 0.2	1.7 ± 0.2	2.2 ± 0.4	2.5 ± 0.6
Arc						
No insect.	1.9 ± 0.1	1.6 ± 0.3	2.0 ± 0.3	1.7 ± 0.2	2.2 ± 0.3	2.6 ± 0.4
Insecticide	2.1 ± 0.1	1.5 ± 0.2	2.0 ± 0.5	1.9 ± 0.4	2.2 ± 0.1	2.4 ± 0.4
OK08						
No insect.	1.5 ± 0.4	1.6 ± 0.2	1.8 ± 0.3	1.6 ± 0.1	1.7 ± 0.4	2.0 ± 0.3
Insecticide	2.2 ± 0.3	1.6 ± 0.5	1.8 ± 0.2	1.6 ± 0.3	1.7 ± 0.4	2.4 ± 0.2
			Alfalf yield g/ha)			
WL318						
No insect.	1.3 ± 0.2	2.3 ± 0.2	1.4 ± 0.5	1.5 ± 0.2	1.8 ± 0.3	2.1 ± 0.2
Insecticide	1.7 ± 0.3	1.6 ± 0.3	1.2 ± 0.2	1.7 ± 0.2	2.0 ± 0.4	2.4 ± 0.6
Arc						
No insect.	0.9 ± 0.2	1.4 ± 0.3	0.9 ± 0.4	1.6 ± 0.1	1.2 ± 0.4	2.1 ± 0.4
Insecticide	1.4 ± 0.2	1.5 ± 0.2	1.6 ± 0.4	1.8 ± 0.3	1.6 ± 0.3	2.3 ± 0.3
OK08						
No insect.	0.3 ± 0.3	0.8 ± 0.3	0.2 ± 0.1	1.1 ± 0.3	0.5 ± 0.4	1.4 ± 0.3
Insecticide	0.8 ± 0.5	1.2 ± 0.4	0.7 ± 0.3	1.5 ± 0.2	0.7 ± 0.2	1.6 ± 0.2

TABLE XVIII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	36.8 ± 5.4	5.5 ± 1.5	28.3 ±17.3	3.8 ± 0.7	26.3 ± 6.2	5.0 ± 1.5
Insecticide	14.0 ± 2.9	4.8 ± 1.4	6.5 ± 3.1	2.0 ± 0.4	5.0 ± 1.7	1.5 ± 0.6
Arc						
No insect.	50.0 ±12.4	10.5 ± 2.4	58.3 ±13.9	4.8 ± 2.5	44.0 ±17.1	17.5 ± 9.5
Insecticide	31.0 ±11.2	3.5 ± 1.5	19.5 ± 5.6	4.5 ± 1.9	27.3 ±10.5	4.0 ± 1.1
OK08						
No insect.	81.8 ±15.6	49.3 ±17.3	88.3 ± 6.1	31.3 ±16.3	79.3 ±13.2	29.8 ±11.2
Insecticide	67.8 ±18.8	27.0 ± 8.3	62.8 ±12.9	7.8 ± 0.7	54.3 ±17.5	33.8 ±11.0

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	0.9	28.1
L.S.D. for harvest management=	0.8	0.7	20.8
L.S.D. for pesticides=	0.2	0.2	4.8

TABLE XIX

FIFTH HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 16 SEPTEMBER 1986, SEASON 4

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	3.6 ± 0.3	3.3 ± 0.1	3.6 ± 0.3	3.5 ± 0.4	3.4 ± 0.4	3.2 ± 0.3
Insecticide	3.0 ± 0.2	2.9 ± 0.3	3.0 ± 0.5	2.9 ± 0.1	3.2 ± 0.2	2.9 ± 0.2
Arc						
No insect.	3.6 ± 0.3	3.0 ± 0.3	4.0 ± 0.6	3.1 ± 0.2	3.4 ± 0.4	3.3 ± 0.3
Insecticide	3.3 ± 0.1	3.1 ± 0.2	3.6 ± 0.5	3.4 ± 0.4	3.3 ± 0.3	2.6 ± 0.3
OK08						
No insect.	2.7 ± 0.4	2.9 ± 0.4	3.0 ± 0.5	3.5 ± 0.2	2.9 ± 0.3	3.5 ± 0.3
Insecticide	3.2 ± 0.2	3.0 ± 0.5	3.5 ± 0.3	3.0 ± 0.1	4.1 ± 0.4	4.4 ± 0.7
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	1.5 ± 0.3	2.9 ± 0.1	2.7 ± 0.3	3.0 ± 0.5	2.4 ± 0.3	3.1 ± 0.2
Insecticide	2.2 ± 0.2	2.8 ± 0.3	2.7 ± 0.5	2.7 ± 0.1	2.9 ± 0.2	2.7 ± 0.2
Arc						
No insect.	0.6 ± 0.1	2.4 ± 0.1	2.2 ± 0.3	2.9 ± 0.2	1.4 ± 0.3	2.4 ± 0.2
Insecticide	1.3 ± 0.4	2.3 ± 0.5	2.1 ± 0.3	3.2 ± 0.3	1.8 ± 0.4	2.4 ± 0.3
OK08						
No insect.	0.2 ± 0.1	0.9 ± 0.3	0.4 ± 0.1	1.9 ± 0.4	0.7 ± 0.5	1.9 ± 0.5
Insecticide	0.6 ± 0.2	1.2 ± 0.1	0.7 ± 0.1	2.5 ± 0.1	1.8 ± 1.0	1.9 ± 0.5

TABLE XIX (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	58.3 ± 9.5	12.0 ± 4.1	23.0 ± 6.6	12.0 ± 9.3	28.0 ± 9.3	5.5 ± 1.7
Insecticide	25.5 ± 2.5	3.5 ± 0.6	9.5 ± 3.7	7.0 ± 4.4	9.0 ± 3.7	5.3 ± 2.5
Arc						
No insect.	82.5 ± 3.2	19.5 ± 5.1	44.0 ± 7.5	7.5 ± 2.1	55.3 ±17.3	25.0 ±11.5
Insecticide	60.3 ±13.7	26.8 ±16.5	35.8 ±13.7	6.5 ± 2.3	42.5 ±14.8	8.8 ± 1.5
OK08						
No insect.	93.0 ± 2.4	63.3 ±17.2	86.8 ± 2.7	44.3 ±11.9	78.3 ±12.6	43.0 ±15.7
Insecticide	79.5 ± 7.6	51.5 ±16.4	78.0 ± 5.0	18.8 ± 3.1	61.8 ±19.3	54.0 ±13.9

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.9	0.9	22.9
L.S.D. for harvest management=	0.9	0.8	21.2
L.S.D. for pesticides=	0.2	0.2	4.8

TABLE XX

FIRST HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 12 MAY 1987, SEASON 5

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	4.1 ± 0.3	3.8 ± 0.5	5.5 ± 0.7	5.3 ± 0.9	4.7 ± 0.7	4.2 ± 0.5
Insecticide	5.7 ± 0.4	4.7 ± 0.5	6.6 ± 0.6	5.5 ± 1.0	6.5 ± 0.3	4.9 ± 0.6
Arc						
No insect.	3.3 ± 0.2	3.4 ± 0.6	4.2 ± 0.4	4.6 ± 0.6	4.2 ± 0.3	3.3 ± 0.4
Insecticide	4.5 ± 0.6	4.6 ± 0.3	5.0 ± 0.8	4.8 ± 0.2	4.3 ± 0.3	4.8 ± 0.8
OK08						
No insect.	2.4 ± 0.4	2.3 ± 1.0	3.7 ± 0.9	3.2 ± 1.0	3.1 ± 0.6	2.5 ± 0.8
Insecticide	3.4 ± 0.9	4.1 ± 1.1	3.7 ± 0.5	4.7 ± 1.0	4.2 ± 0.9	4.0 ± 0.6
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	1.4 ± 0.4	3.0 ± 0.5	1.7 ± 0.6	4.0 ± 1.5	1.2 ± 0.6	3.3 ± 0.8
Insecticide	3.1 ± 1.0	4.4 ± 0.6	3.3 ± 1.0	4.4 ± 1.2	3.7 ± 0.7	4.1 ± 0.4
Arc						
No insect.	1.0 ± 0.5	2.2 ± 0.2	1.4 ± 0.6	3.7 ± 0.9	0.6 ± 0.3	1.6 ± 0.5
Insecticide	2.1 ± 0.5	3.8 ± 0.3	2.9 ± 0.7	3.5 ± 0.5	2.0 ± 0.6	4.1 ± 0.5
OK08						
No insect.	0.1 ± 0.1	1.2 ± 0.8	0.2 ± 0.1	1.7 ± 0.6	0.1 ± 0.1	1.6 ± 0.7
Insecticide	0.9 ± 0.6	3.0 ± 1.2	0.6 ± 0.3	3.3 ± 1.2	1.2 ± 0.8	2.1 ± 0.9

TABLE XX (Continued)

Cultivar	Fall harvested No herb.	Fall harvested Herbicide	Winter grazed No herb.	Winter grazed Herbicide	Unharvested No herb.	Unharvested Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	66.3 ± 9.4	20.0 ± 9.9	71.5 ± 7.5	24.5 ±20.9	74.3 ±12.8	23.5 ± 9.9
Insecticide	48.5 ±16.4	7.0 ± 5.4	52.5 ±12.0	21.8 ±12.0	43.5 ± 8.4	15.8 ± 6.5
Arc						
No insect.	71.8 ±14.4	28.0 ±14.5	69.0 ± 9.6	21.8 ±12.8	85.8 ± 7.0	51.5 ±16.0
Insecticide	55.5 ± 5.6	17.0 ± 5.2	43.3 ± 7.0	29.0 ± 8.1	53.8 ±12.5	11.0 ± 7.0
OK08						
No insect.	94.8 ± 1.3	49.8 ±18.8	93.0 ± 2.7	44.0 ± 9.5	95.3 ± 0.5	39.8 ±17.5
Insecticide	81.0 ± 9.1	25.8 ±15.5	83.3 ± 6.0	33.5 ±14.5	78.0 ±11.4	52.5 ±14.6

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.6	1.9	29.6
L.S.D. for harvest management=	1.2	1.5	27.9
L.S.D. for pesticides=	0.3	0.4	6.9

TABLE XXI

SECOND HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 17 JUNE 1987, SEASON 5

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.2 ± 0.3	3.2 ± 0.1	2.5 ± 0.2	3.4 ± 0.1	1.7 ± 0.2	3.1 ± 0.1
Insecticide	3.2 ± 0.2	3.9 ± 0.3	3.3 ± 0.3	3.7 ± 0.2	3.4 ± 0.2	4.0 ± 0.2
Arc						
No insect.	2.4 ± 0.6	3.2 ± 0.4	2.1 ± 0.3	3.6 ± 0.4	2.0 ± 0.4	3.1 ± 0.3
Insecticide	2.6 ± 0.3	3.6 ± 0.2	3.0 ± 0.3	3.9 ± 0.3	2.9 ± 0.4	4.1 ± 0.4
OK08						
No insect.	1.3 ± 0.3	2.3 ± 0.2	1.2 ± 0.1	2.7 ± 0.3	1.0 ± 0.2	2.1 ± 0.2
Insecticide	1.8 ± 0.6	3.1 ± 0.3	2.0 ± 0.3	3.6 ± 0.3	2.0 ± 0.5	2.4 ± 0.5
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	1.8 ± 0.3	3.0 ± 0.1	2.2 ± 0.1	3.0 ± 0.3	1.3 ± 0.3	2.6 ± 0.2
Insecticide	3.0 ± 0.2	3.5 ± 0.3	2.9 ± 0.4	3.6 ± 0.2	3.2 ± 0.2	3.9 ± 0.2
Arc						
No insect.	1.9 ± 0.5	2.4 ± 0.6	1.6 ± 0.4	3.0 ± 0.7	1.7 ± 0.5	2.4 ± 0.5
Insecticide	2.2 ± 0.4	3.3 ± 0.2	2.5 ± 0.5	3.3 ± 0.7	2.5 ± 0.5	3.9 ± 0.4
OK08						
No insect.	0.5 ± 0.3	0.8 ± 0.3	0.7 ± 0.2	1.8 ± 0.5	0.4 ± 0.1	1.2 ± 0.4
Insecticide	1.2 ± 0.8	2.3 ± 0.6	1.3 ± 0.4	2.5 ± 0.5	1.4 ± 0.7	1.4 ± 0.7

TABLE XXI (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	16.5 ± 2.7	5.8 ± 1.1	13.0 ± 0.7	12.0 ± 6.9	24.3 ± 7.4	14.5 ± 5.9
Insecticide	7.0 ± 2.0	8.8 ± 5.4	10.5 ± 6.5	4.5 ± 1.9	4.8 ± 1.1	4.5 ± 1.3
Arc						
No insect.	25.0 ±11.8	26.8 ±11.3	25.0 ±13.5	18.5 ±15.5	22.5 ±10.9	24.8 ±11.0
Insecticide	13.8 ± 5.8	8.3 ± 4.6	19.5 ±10.2	16.0 ±13.0	16.8 ± 5.0	5.0 ± 1.5
OK08						
No insect.	66.0 ±18.3	64.8 ±11.9	38.5 ±19.4	38.0 ±14.3	52.5 ±12.7	43.8 ±14.8
Insecticide	52.5 ±20.3	28.0 ±13.2	34.8 ±16.9	31.8 ±13.6	31.3 ±20.0	50.8 ±16.7

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.9	1.1	24.6
L.S.D. for harvest management=	0.7	0.8	19.7
L.S.D. for pesticides=	0.2	0.2	4.1

TABLE XXII

THIRD HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 21 JULY 1987, SEASON 5

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.1 ± 0.3	3.0 ± 0.2	2.7 ± 0.1	2.5 ± 0.1	2.1 ± 0.2	2.7 ± 0.1
Insecticide	2.9 ± 0.2	2.6 ± 0.2	2.3 ± 0.2	3.2 ± 0.2	3.0 ± 0.3	2.6 ± 0.2
Arc						
No insect.	1.9 ± 0.6	2.1 ± 0.3	1.9 ± 0.4	2.0 ± 0.2	2.0 ± 0.4	2.5 ± 0.4
Insecticide	2.0 ± 0.4	2.4 ± 0.2	2.3 ± 0.3	2.4 ± 0.2	2.3 ± 0.3	2.6 ± 0.2
OK08						
No insect.	0.8 ± 0.2	1.6 ± 0.4	1.0 ± 0.2	1.9 ± 0.2	1.3 ± 0.3	1.6 ± 0.4
Insecticide	1.7 ± 0.4	2.2 ± 0.3	1.3 ± 0.4	2.4 ± 0.4	1.4 ± 0.2	1.8 ± 0.3
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	1.2 ± 0.4	2.7 ± 0.2	1.5 ± 0.2	2.4 ± 0.2	0.9 ± 0.4	2.3 ± 0.4
Insecticide	2.6 ± 0.2	2.5 ± 0.2	1.8 ± 0.2	3.1 ± 0.2	2.5 ± 0.3	2.6 ± 0.2
Arc						
No insect.	1.5 ± 0.5	1.9 ± 0.3	1.3 ± 0.5	1.8 ± 0.2	0.8 ± 0.3	1.6 ± 0.5
Insecticide	1.4 ± 0.5	2.3 ± 0.2	1.8 ± 0.3	2.1 ± 0.3	1.5 ± 0.4	2.5 ± 0.2
OK08						
No insect.	0.2 ± 0.2	0.8 ± 0.5	0.2 ± 0.2	0.6 ± 0.2	0.1 ± 0.1	0.6 ± 0.4
Insecticide	0.5 ± 0.5	1.3 ± 0.7	0.6 ± 0.3	2.0 ± 0.5	0.6 ± 0.3	1.0 ± 0.5

TABLE XXII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	45.8 ±16.4	7.3 ± 2.0	41.0 ± 8.9	3.3 ± 0.9	60.3 ±15.7	18.3 ±11.0
Insecticide	11.0 ± 2.5	3.8 ± 1.1	21.0 ± 4.1	2.0 ± 0.4	15.5 ± 7.3	2.8 ± 0.5
Arc						
No insect.	27.5 ± 8.3	10.0 ± 3.9	41.3 ±15.7	8.5 ± 3.3	62.0 ±14.1	41.5 ±15.8
Insecticide	37.8 ±11.0	5.0 ± 2.3	22.3 ± 6.6	14.3 ± 8.6	37.5 ± 7.7	3.5 ± 0.9
OK08						
No insect.	86.8 ±11.9	63.3 ±19.5	85.0 ±11.4	64.3 ±14.7	92.3 ± 2.2	70.0 ±15.0
Insecticide	80.5 ±16.5	48.0 ±23.5	67.8 ±15.6	19.8 ±7.3	54.0 ±17.9	53.8 ±20.3

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	0.8	1.0	32.6
L.S.D. for harvest management=	0.7	0.8	26.5
L.S.D. for pesticides=	0.2	0.2	6.0

TABLE XXIII

FOURTH HARVEST YIELD OF ALFALFA FORAGE ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 26 AUGUST 1987, SEASON 5

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Total forage yield (Mg/ha)			
WL318						
No insect.	2.5 ± 0.3	3.6 ± 0.3	2.4 ± 0.2	3.2 ± 0.6	2.7 ± 0.5	3.3 ± 0.2
Insecticide	3.3 ± 0.5	3.1 ± 0.3	3.3 ± 0.4	3.0 ± 0.2	3.7 ± 0.2	4.0 ± 0.3
Arc						
No insect.	2.5 ± 0.5	3.1 ± 0.4	2.7 ± 0.6	3.5 ± 0.4	2.3 ± .4	3.8 ± 0.6
Insecticide	3.0 ± 0.6	3.1 ± 0.7	2.9 ± 0.5	3.8 ± 0.5	3.2 ± .3	3.1 ± 0.3
OK08						
No insect.	1.4 ± 0.2	2.7 ± 0.3	2.2 ± 0.3	3.0 ± 0.6	2.2 ± 0.1	2.9 ± 0.5
Insecticide	3.0 ± 0.2	2.7 ± 0.7	2.9 ± 0.2	3.3 ± 0.6	3.2 ± 0.5	3.0 ± 0.2
			Alfalfa yield (Mg/ha)			
WL318						
No insect.	0.5 ± 0.3	2.0 ± 0.3	0.5 ± 0.2	2.7 ± 0.6	0.4 ± 0.2	2.0 ± 0.5
Insecticide	1.7 ± 0.3	2.5 ± 0.2	1.4 ± 0.3	2.5 ± 0.3	1.7 ± 0.4	3.5 ± 0.2
Arc						
No insect.	0.7 ± 0.3	1.5 ± 0.6	0.2 ± 0.1	2.4 ± 0.6	0.2 ± 0.1	1.3 ± 0.6
Insecticide	0.8 ± 0.4	2.5 ± 0.7	0.9 ± 0.4	2.4 ± 0.6	0.6 ± 0.2	2.6 ± 0.4
OK08						
No insect.	0.1 ± 0.1	0.5 ± 0.3	0.1 ± 0.1	0.3 ± 0.1	0.1 ± 0.1	0.7 ± 0.5
Insecticide	0.3 ± 0.1	0.5 ± 0.2	0.1 ± 0.1	0.9 ± 0.4	0.2 ± 0.1	0.5 ± 0.4

TABLE XXIII (Continued)

Cultivar	Fall harvested		Winter grazed		Unharvested	
	No herb.	Herbicide	No herb.	Herbicide	No herb.	Herbicide
			Percentage of weeds in forage			
WL318						
No insect.	80.8 ± 9.2	45.0 ± 4.3	77.3 ± 7.1	16.0 ± 5.0	86.5 ± 5.4	37.5 ±13.3
Insecticide	47.3 ± 5.5	19.8 ± 3.2	56.0 ± 8.4	14.5 ± 6.8	56.0 ±11.7	12.8 ± 4.2
Arc						
No insect.	74.8 ±11.1	53.5 ±17.7	91.8 ± 3.8	34.3 ±10.2	93.5 ± 2.6	65.3 ±15.5
Insecticide	74.5 ±12.6	21.8 ± 6.9	72.3 ± 7.2	39.3 ± 8.8	78.8 ± 9.3	18.0 ± 4.6
OK08						
No insect.	98.0 ± 0.7	80.5 ±10.8	98.5 ± 0.3	89.5 ± 2.5	97.8 ± 0.6	75.8 ±19.6
Insecticide	85.3 ± 8.6	67.5 ±21.7	95.0 ± 1.7	75.0 ± 8.6	86.3 ±10.1	85.0 ± 9.7

	Total	Alfalfa	% weeds
L.S.D. for cultivar=	1.1	1.0	27.9
L.S.D. for harvest management=	1.0	0.8	22.6
L.S.D. for pesticides=	0.2	0.2	4.8

TABLE XXIV

STAND PERSISTENCE OF ALFALFA ($\bar{x} \pm SE$) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1983-1984, SEASONS 1-2

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			9 May 1983			
WL318						
No insect.	31.0 ± 1.9	32.6 ± 1.8	31.0 ± 0.7	32.6 ± 1.7	31.2 ± 0.4	30.3 ± 2.4
Insecticide	31.9 ± 1.5	29.7 ± 2.0	26.8 ± 1.3	29.8 ± 1.1	31.5 ± 1.1	30.5 ± 0.8
Arc						
No insect.	28.7 ± 1.8	33.2 ± 1.1	34.0 ± 0.5	34.2 ± 1.5	33.4 ± 1.0	29.9 ± 0.8
Insecticide	32.1 ± 1.7	31.1 ± 1.3	31.1 ± 1.0	32.8 ± 1.2	29.3 ± 0.8	33.4 ± 1.0
OK08						
No insect.	29.3 ± 2.0	28.2 ± 1.6	33.3 ± 0.8	32.6 ± 1.5	28.9 ± 1.7	31.3 ± 0.9
Insecticide	31.7 ± 2.1	28.6 ± 1.5	31.1 ± 0.5	29.9 ± 0.8	28.1 ± 1.5	30.8 ± 3.3
			8 May 1984			
WL318						
No insect.	22.5 ± 1.9	24.5 ± 0.8	25.3 ± 0.7	26.4 ± 1.3	24.6 ± 0.5	25.6 ± 1.0
Insecticide	25.4 ± 1.0	26.0 ± 2.2	26.9 ± 0.9	23.2 ± 1.2	24.4 ± 0.9	25.5 ± 1.4
Arc						
No insect.	25.1 ± 1.1	23.6 ± 0.7	26.0 ± 0.5	26.5 ± 1.8	24.5 ± 1.4	23.3 ± 1.8
Insecticide	24.3 ± 1.0	25.0 ± 0.6	25.9 ± 1.3	25.9 ± 1.5	21.8 ± 0.8	26.1 ± 2.2
OK08						
No insect.	21.1 ± 1.4	21.9 ± 1.3	24.8 ± 1.1	22.7 ± 3.0	23.3 ± 0.8	25.9 ± 0.8
Insecticide	22.4 ± 0.9	24.0 ± 1.6	22.6 ± 1.3	25.0 ± 1.2	24.1 ± 0.8	23.0 ± 1.1

	9 May 1983	8 May 1984
LSD for cultivar=	4.1	3.3
LSD for harvest management=	4.1	3.7
LSD for pesticide=	0.7	0.8

TABLE XXV

STAND PERSISTENCE OF ALFALFA ($\bar{x} \pm SE$) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1985, SEASONS 3

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			4 April 1985			
WL318						
No insect.	22.5 ± 1.9	24.5 ± 0.8	25.3 ± 0.7	26.4 ± 1.3	24.6 ± 0.5	25.6 ± 1.0
Insecticide	25.4 ± 1.0	26.0 ± 2.2	26.9 ± 0.9	23.2 ± 1.2	24.4 ± 0.9	25.5 ± 1.4
Arc						
No insect.	25.1 ± 1.1	23.6 ± 0.7	26.0 ± 0.5	26.5 ± 1.8	24.5 ± 1.4	23.3 ± 1.8
Insecticide	24.3 ± 1.0	25.0 ± 0.6	25.9 ± 1.3	25.9 ± 1.5	21.8 ± 0.8	26.1 ± 2.2
OK08						
No insect.	21.1 ± 1.4	21.9 ± 1.3	24.8 ± 1.1	22.7 ± 3.0	23.3 ± 0.8	25.9 ± 0.8
Insecticide	22.4 ± 0.9	24.0 ± 1.6	22.6 ± 1.3	25.0 ± 1.2	24.1 ± 0.8	23.0 ± 1.1

	4 April 1985
LSD for cultivar=	1.3
LSD for harvest management=	1.2
LSD for pesticide=	0.9

TABLE XXVI

STAND PERSISTENCE OF ALFALFA ($\bar{x} \pm$ SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1986, SEASONS 4

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			15 April			
WL318						
No insect.	15.0 ± 1.3	18.6 ± 1.0	19.2 ± 2.3	21.5 ± 3.3	13.5 ± 1.6	18.0 ± 2.8
Insecticide	20.5 ± 1.3	20.7 ± 1.8	23.6 ± 1.7	24.0 ± 1.1	19.9 ± 0.3	21.6 ± 1.0
Arc						
No insect.	13.6 ± 0.8	17.2 ± 2.4	17.9 ± 0.8	20.1 ± 1.0	13.2 ± 3.4	18.7 ± 1.8
Insecticide	19.4 ± 1.5	20.1 ± 0.8	17.7 ± 1.0	20.5 ± 1.0	16.0 ± 0.9	20.2 ± 1.3
OK08						
No insect.	5.0 ± 2.6	11.4 ± 1.5	6.9 ± 1.4	12.0 ± 2.5	3.8 ± 0.8	12.6 ± 3.5
Insecticide	10.2 ± 2.5	17.1 ± 1.9	15.1 ± 1.9	18.1 ± 1.4	12.7 ± 2.6	13.9 ± 2.6
			16 May			
WL318						
No insect.	18.3 ± 1.2	18.9 ± 1.9	19.7 ± 2.6	19.7 ± 2.1	16.5 ± 2.2	16.5 ± 2.3
Insecticide	20.8 ± 1.0	22.8 ± 1.3	21.1 ± 2.3	23.4 ± 1.7	20.4 ± 1.9	21.3 ± 1.9
Arc						
No insect.	14.7 ± 2.7	14.5 ± 1.2	15.3 ± 1.2	19.2 ± 0.8	14.3 ± 1.7	15.1 ± 1.0
Insecticide	16.9 ± 2.3	16.5 ± 0.8	17.8 ± 0.7	20.3 ± 0.3	16.8 ± 2.3	17.3 ± 1.3
OK08						
No insect.	5.7 ± 1.8	8.9 ± 2.2	9.6 ± 0.8	12.0 ± 1.0	6.5 ± 1.3	13.3 ± 0.9
Insecticide	10.4 ± 2.1	17.2 ± 3.1	14.8 ± 2.0	14.5 ± 2.6	13.1 ± 3.3	15.6 ± 2.5

TABLE XXVI (Continued)

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			2 July			
WL318						
No insect.	16.4 ± 1.4	18.2 ± 1.2	19.5 ± 2.8	15.8 ± 2.2	17.6 ± 0.6	15.6 ± 1.8
Insecticide	18.7 ± 1.3	18.7 ± 1.5	18.3 ± 1.9	18.3 ± 3.2	18.0 ± 1.7	18.0 ± 1.4
Arc						
No insect.	14.1 ± 1.0	11.7 ± 1.8	13.8 ± 1.4	15.3 ± 0.5	14.1 ± 2.5	16.9 ± 1.7
Insecticide	15.4 ± 3.0	15.6 ± 0.6	18.4 ± 0.9	15.2 ± 1.2	15.0 ± 0.6	18.6 ± 1.6
OK08						
No insect.	4.5 ± 1.8	10.0 ± 2.4	7.2 ± 1.8	8.4 ± 1.1	8.8 ± 2.0	11.3 ± 1.5
Insecticide	11.4 ± 1.9	12.9 ± 1.1	12.5 ± 2.8	13.4 ± 2.2	11.2 ± 2.9	10.3 ± 0.8

	15 April 1986	16 May 1986	2 July 1986
LSD for cultivar=	5.1	4.9	5.1
LSD for harvest management=	4.6	4.3	4.4
LSD for pesticide=	1.0	1.0	1.0

TABLE XXVII

STAND PERSISTENCE OF ALFALFA ($\bar{x}$ ± SE) AFTER IMPOSITION OF HARVEST AND PESTICIDE TREATMENTS IN THREE CULTIVARS, CHICKASHA, OKLAHOMA, 1987, SEASONS 5

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			28 April			
WL318						
No insect.	3.2 ± 1.5	6.1 ± 2.0	6.9 ± 0.9	11.3 ± 3.9	3.7 ± 1.7	8.1 ± 4.3
Insecticide	8.5 ± 2.2	11.2 ± 4.3	11.1 ± 4.4	12.0 ± 4.2	8.5 ± 2.0	11.2 ± 3.1
Arc						
No insect.	5.2 ± 2.0	6.9 ± 1.3	5.2 ± 0.6	8.8 ± 2.4	3.9 ± 1.6	6.7 ± 2.2
Insecticide	5.6 ± 2.5	12.3 ± 1.4	8.8 ± 1.7	10.5 ± 2.6	8.1 ± 2.0	12.5 ± 1.7
OK08						
No insect.	3.3 ± 2.3	5.2 ± 1.7	4.5 ± 2.0	7.8 ± 0.7	1.3 ± 0.6	6.2 ± 1.7
Insecticide	5.6 ± 3.1	7.5 ± 2.5	6.0 ± 2.5	11.3 ± 1.5	9.4 ± 2.2	7.4 ± 3.4
			10 June			
WL318						
No insect.	10.1 ± 2.1	15.0 ± 1.8	12.8 ± 1.4	17.0 ± 1.6	8.4 ± 1.4	13.3 ± 1.1
Insecticide	15.9 ± 2.3	18.4 ± 2.6	14.8 ± 1.7	15.6 ± 1.8	15.0 ± 2.2	15.5 ± 2.2
Arc						
No insect.	6.6 ± 2.2	10.1 ± 1.4	8.1 ± 1.3	11.8 ± 1.1	5.1 ± 1.6	9.4 ± 2.1
Insecticide	10.6 ± 3.6	17.0 ± 1.6	13.1 ± 1.3	13.4 ± 3.0	8.4 ± 0.8	17.8 ± 2.8
OK08						
No insect.	1.6 ± 1.3	5.9 ± 1.7	3.6 ± 1.5	6.2 ± 1.9	2.8 ± 1.0	8.4 ± 3.3
Insecticide	4.0 ± 2.5	10.2 ± 5.0	5.1 ± 2.0	11.2 ± 2.5	6.3 ± 2.3	6.0 ± 3.1

TABLE XXVII (Continued)

Cultivar	Fall cut		Winter grazed		Unharvested	
	No herb.	Herbicides	No herb.	Herbicides	No herb.	Herbicides
			14 July			
WL318						
No insect.	6.5 ± 1.1	12.5 ± 1.3	10.9 ± 2.4	13.1 ± 1.3	9.1 ± 1.6	14.8 ± 1.2
Insecticide	11.5 ± 0.9	14.4 ± 1.2	13.7 ± 2.5	16.3 ± 1.5	15.6 ± 1.3	15.9 ± 1.0
Arc						
No insect.	6.5 ± 2.3	10.1 ± 1.9	5.7 ± 1.4	12.6 ± 2.3	8.7 ± 2.0	7.9 ± 0.8
Insecticide	8.2 ± 2.3	14.4 ± 2.9	9.2 ± 1.4	12.3 ± 2.8	10.3 ± 0.8	15.1 ± 2.8
OK08						
No insect.	4.8 ± 4.3	4.8 ± 1.5	2.0 ± 0.7	5.1 ± 1.2	2.3 ± 0.7	4.8 ± 2.1
Insecticide	2.8 ± 1.9	7.5 ± 1.4	3.9 ± 1.0	8.2 ± 1.2	5.4 ± 2.1	4.4 ± 2.7

	28 April 1987	10 June 1987	14 July 1987
LSD for cultivar=	6.4	5.7	4.8
LSD for harvest management=	1.7	4.4	3.7
LSD for pesticide=	1.1	1.0	0.9

APPENDIX B

SIGNIFICANCE OF ANALYSIS OF VARIANCE

TABLE I

ANALYSIS OF VARIANCE FOR HARVEST YIELD OF ALFALFA, CHICKASHA, OKLAHOMA, 1983

Source	df	5 May				16 June		
		Total	Alfalfa	%Weeds	%Protein	Total	Alfalfa	%Weeds
Cultivar (C)	2, 6	5.40 *	6.71 *	0.99	1.26	0.07	0.09	1.00
Harvest mgt. (M)	2, 6	21.28 *	13.39 *	0.22	1.49	2.37	2.37	.
C × M	4,12	0.45	0.28	0.78	0.21	0.99	0.98	.
Herbicide (H)	1,81	19.15 *	5.47 *	79.20 *	2.01	7.26 *	7.67 *	3.00
Insecticide (I)	1,81	13.49 *	17.57 *	9.99 *	0.28	12.68 *	13.16 *	3.00
H × I	1,81	0.02	0.19	2.22	0.00	0.01	0.04	3.00
C × H	2,81	1.59	1.32	1.03	2.79	0.14	0.09	3.00
C × I	2,81	2.32	3.09	2.87	1.70	0.52	0.37	3.00
C × H × I	2,81	0.37	0.33	0.07	0.88	0.37	0.40	3.00
M × H	2,81	0.92	0.84	1.84	1.47	1.68	1.65	0.00
M × I	2,81	0.21	0.23	0.53	0.89	3.54 *	3.45 *	0.00
M × H × I	2,81	0.08	0.15	0.89	0.59	2.11	2.06	0.00
C × M × H	4,81	1.91	1.22	1.33	1.14	0.17	0.17	0.00
C × M × I	4,81	0.79	0.80	0.23	0.16	2.56 *	2.51 *	0.00
C × M × H × I	4,81	2.04	2.51	1.29	1.14	0.30	0.29	0.00

TABLE I (Continued)

Source	df	17 July Total	17 July Alfalfa	17 July %Weeds	15 September Total	15 September Alfalfa
Cultivar (C)	2, 6	0.34	0.33	1.00	0.83	0.83
Harvest mgt. (M)	2, 6	1.13	1.11	1.00	0.77	0.77
C × M	4,12	1.10	1.08	1.00	2.26	2.26
Herbicide (H)	1,81	0.74	0.76	0.22	0.40	0.40
Insecticide (I)	1,81	0.03	0.04	1.98	0.61	0.61
H × I	1,81	0.50	0.45	0.61	0.04	0.04
C × H	2,81	1.91	1.84	0.07	0.78	0.78
C × I	2,81	0.56	0.55	0.22	0.74	0.74
C × H × I	2,81	0.60	0.58	0.17	1.97	1.97
M × H	2,81	0.61	0.55	1.39	0.41	0.41
M × I	2,81	2.45	2.40	0.51	2.26	2.26
M × H × I	2,81	0.14	0.13	0.46	0.12	0.12
C × M × H	4,81	0.72	0.77	2.12	1.36	1.36
C × M × I	4,81	0.95	0.97	1.17	1.38	1.38
C × M × H × I	4,81	0.61	0.62	1.34	1.72	1.72

* significant at $P < 0.05$.

TABLE II

ANALYSIS OF VARIANCE FOR HARVEST YIELD OF ALFALFA, CHICKASHA, OKLAHOMA, 1984

Source	df	8 May				18 June	
		Total	Alfalfa	%Weeds	%Protein	Total	Alfalfa
Cultivar (C)	2, 6	3.35	3.77	0.84	44.58 *	4.17	4.17
Harvest mgt. (M)	2, 6	1.82	2.33	7.59 *	6.78	0.18	0.18
C × M	4,12	0.12	0.12	0.65	1.85	0.04	0.04
Herbicide (H)	1,81	1.72	0.42	40.53 *	9.76 *	0.00	0.00
Insecticide (I)	1,81	0.13	0.01	7.25 *	0.29	0.02	0.02
H × I	1,81	1.40	0.82	6.61 *	0.33	0.46	0.46
C × H	2,81	0.35	0.18	3.85 *	0.21	0.10	0.10
C × I	2,81	0.35	0.22	1.29	2.30	0.85	0.85
C × H × I	2,81	0.64	0.48	1.56	0.39	0.55	0.55
M × H	2,81	1.02	0.69	3.26 *	1.19	1.01	1.01
M × I	2,81	0.30	0.31	0.50	1.49	1.66	1.66
M × H × I	2,81	1.92	2.03	0.64	4.05 *	0.45	0.45
C × M × H	4,81	0.62	0.72	0.39	1.89	0.61	0.61
C × M × I	4,81	0.43	0.53	1.09	3.18 *	0.45	0.45
C × M × H × I	4,81	1.99	2.10	0.87	1.51	0.32	0.32

TABLE II (Continued)

Source	df	19 July		6 September		
		Total	Alfalfa	Total	Alfalfa	%Weeds
Cultivar (C)	2, 6	2.63	2.63	1.17	2.47	2.55
Harvest mgt. (M)	2, 6	4.34	4.34	0.72	0.28	2.55
C × M	4,12	0.28	0.28	0.30	0.31	0.84
Herbicide (H)	1,81	1.69	1.69	0.27	1.49	6.11 *
Insecticide (I)	1,81	0.25	0.25	1.26	2.21	2.42
H × I	1,81	0.06	0.06	0.36	0.05	2.42
C × H	2,81	0.81	0.81	1.01	2.10	2.94
C × I	2,81	1.73	1.73	0.90	1.16	0.76
B × H × I	2,81	1.61	1.61	0.82	1.17	0.76
M × H	2,81	1.10	1.10	3.30	2.22	2.94
M × I	2,81	1.09	1.09	0.17	0.24	0.76
M × H × I	2,81	0.94	0.94	0.10	0.13	0.76
C × M × H	4,81	1.34	1.34	2.32	2.21	1.13
C × M × I	4,81	1.04	1.04	0.93	0.72	0.46
C × M × H × I	4,81	2.84 *	2.84 *	0.95	0.92	0.46

* significant at $P < 0.05$.

TABLE III

ANALYSIS OF VARIANCE FOR HARVEST YIELD OF ALFALFA, CHICKASHA, OKLAHOMA, 1985

Source	df	3 May Total	3 May Alfalfa	3 May %Weeds	3 May %Protein	14 June Total	14 June Alfalfa	14 June %Weeds
Cultivar (C)	2, 6	13.26 *	5.58 *	1.56	14.73	0.69	0.91	10.44 *
Harvest mgt. (M)	2, 6	0.53	2.79	1.52	0.64	0.35	0.34	0.54
C × M	4,12	0.40	0.58	1.26	0.35	0.78	0.93	0.59
Herbicide (H)	1,81	1.98	10.44 *	12.28 *	0.01	0.12	0.08	0.99
Insecticide (I)	1,81	13.75 *	20.75 *	6.71 *	0.07	0.02	0.06	1.22
H × I	1,81	1.18	0.00	1.79	1.06	0.96	0.91	0.02
C × H	2,81	1.95	2.39	1.38	1.06	0.43	0.43	0.18
C × I	2,81	3.22 *	0.80	0.42	0.47	1.11	1.00	0.15
C × H × I	2,81	2.11	1.25	0.61	0.29	0.46	0.50	0.18
M × H	2,81	1.80	1.53	3.57 *	0.07	1.01	1.06	2.72
M × I	2,81	0.42	0.07	0.23	1.25	0.70	0.56	0.89
M × H × I	2,81	1.10	0.16	0.55	0.62	0.50	0.58	0.68
C × M × H	4,81	0.73	1.44	1.47	0.26	0.65	0.81	2.15
C × M × I	4,81	0.36	1.42	1.45	0.55	0.48	0.47	0.90
C × M × H × I	4,81	1.21	0.26	0.49	0.15	3.43 *	3.59	1.02

TABLE III (Continued)

Source	df	12 July Total	12 July Alfalfa	12 July %Weeds	15 August Total	15 August Alfalfa	15 August %Weeds
Cultivar (C)	2, 6	4.88	5.65 *	4.78	0.70	0.76	5.03
Harvest mgt. (M)	2, 6	1.12	2.83	2.09	0.59	2.77	3.90
C × M	4,12	0.64	1.02	1.53	0.44	0.70	2.65
Herbicide (H)	1,81	0.58	0.01	0.77	0.06	3.44	8.29 *
Insecticide (I)	1,81	0.14	0.94	1.47	0.66	0.29	4.24 *
H × I	1,81	0.26	0.19	0.02	0.27	0.17	2.16
C × H	2,81	1.04	0.14	0.52	0.25	1.02	3.10
C × I	2,81	1.54	0.71	0.62	1.21	0.97	0.63
C × H × I	2,81	1.07	0.68	0.15	0.47	0.89	0.62
M × H	2,81	1.26	3.38 *	4.37 *	1.07	1.68	7.81 *
M × I	2,81	1.74	1.00	1.29	1.44	1.68	1.13
M × H × I	2,81	0.91	0.36	2.69	0.37	0.54	0.35
C × M × H	4,81	0.27	0.71	3.71 *	1.02	2.07	2.88 *
C × M × I	4,81	0.94	0.57	1.60	0.61	0.98	2.09
C × M × H × I	4,81	2.09	2.74 *	2.49 *	0.07	0.14	0.56

TABLE III (Continued)

Source	df	13 September Total	Alfalfa	%Weeds
Cultivar (C)	2, 6	0.01	0.53	4.36
Harvest mgt. (M)	2, 6	1.15	9.98 *	2.10
C × M	4,12	0.49	1.57	1.71
Herbicide (H)	1,81	0.24	0.26	6.31 *
Insecticide (I)	1,81	3.84	4.91 *	2.84
H × I	1,81	1.61	3.74	6.31 *
C × H	2,81	0.50	1.55	4.05 *
C × I	2,81	2.66	2.73	0.67
C × H × I	2,81	0.48	0.86	2.70
M × H	2,81	0.75	0.55	3.26 *
M × I	2,81	2.28	2.25	0.29
M × H × I	2,81	0.11	0.15	0.50
C × M × H	4,81	0.69	0.78	2.23
C × M × I	4,81	1.08	1.51	1.13
C × M × H × I	4,81	2.45	1.16	0.34

* significant at $P < 0.05$.

TABLE IV

ANALYSIS OF VARIANCE FOR HARVEST YIELD
OF ALFALFA, CHICKASHA, OKLAHOMA,
1986

Source	df	29 April				10 June			
		Total	Alfalfa	%Weeds	%Protein	Total	Alfalfa	%Weeds	%Protein
Cultivar (C)	2, 6	13.82 *	10.09 *	7.29 *	1.89	14.23 *	23.32 *	22.47 *	1.85
Harvest mgt. (M)	2, 6	17.11 *	14.28 *	9.56 *	2.49	6.36 *	6.43 *	5.35 *	1.52
C × M	4,12	0.15	0.09	0.22	2.70	0.42	1.45	2.46	0.48
Herbicide (H)	1,81	14.84 *	101.56 *	401.80 *	50.32 *	0.00	28.76 *	81.77 *	8.34 *
Insecticide (I)	1,81	184.97 *	387.72 *	92.94 *	0.34	28.94 *	93.90 *	91.56 *	0.06
H × I	1,81	0.12	7.28 *	51.93 *	2.36	0.28	5.45 *	21.85 *	1.10
C × H	2,81	0.27	2.82	15.61 *	9.61 *	0.59	5.01 *	13.73 *	2.24
C × I	2,81	0.82	2.85	2.01	0.05	4.96 *	5.64 *	9.24 *	0.37
C × H × I	2,81	0.15	0.94	0.52	2.67	0.54	0.65	0.24	2.51
M × H	2,81	1.14	1.67	5.23 *	0.91	1.19	1.76	2.29	1.27
M × I	2,81	0.09	0.09	0.65	0.03	3.73 *	4.01 *	2.04	0.27
M × H × I	2,81	0.20	0.18	0.52	0.08	0.16	0.23	0.14	2.02
C × M × H	4,81	0.89	0.86	0.64	0.71	1.02	0.62	0.58	0.89
C × M × I	4,81	0.51	1.47	1.02	1.58	0.28	0.08	0.15	2.25
C × M × H × I	4,81	0.64	0.56	1.11	2.22	1.60	1.23	0.16	3.07 *

TABLE IV (Continued)

Source	df	10 July				8 August			
		Total	Alfalfa	%Weeds	%Protein	Total	Alfalfa	%Weeds	%Protein
Cultivar (C)	2, 6	5.05	8.36 *	10.72 *	6.33 *	1.42	8.31 *	9.43 *	7.58 *
Harvest mgt. (M)	2, 6	2.20	3.91	5.72 *	2.29	16.82 *	11.11 *	1.57	4.71
C × M	4,12	0.53	0.42	1.97	2.70	1.46	1.08	0.31	0.13
Herbicide (H)	1,81	3.79	22.76 *	24.20 *	3.47	0.02	34.43 *	150.89 *	27.25 *
Insecticide (I)	1,81	20.37 *	33.96 *	16.36 *	1.02	0.00	7.02 *	39.18 *	6.83 *
H × I	1,81	0.30	0.83	3.92	0.48	0.00	1.66	9.85 *	2.23
C × H	2,81	1.03	3.13 *	5.03 *	0.28	0.25	1.34	10.36 *	9.65 *
C × I	2,81	0.57	0.79	2.72	0.61	1.63	1.39	0.48	2.19
C × H × I	2,81	0.04	0.17	0.35	0.41	0.33	0.26	0.61	2.16
M × H	2,81	0.92	1.03	1.07	1.67	2.08	0.99	1.65	0.29
M × I	2,81	3.22 *	2.59	0.30	0.84	0.04	0.12	0.54	0.00
M × H × I	2,81	0.36	0.47	0.19	0.02	2.17	0.93	0.51	0.31
C × M × H	4,81	0.46	1.28	2.43	1.10	0.84	0.54	0.87	2.51 *
C × M × I	4,81	2.69 *	1.26	0.09	0.98	0.65	0.64	0.32	2.30
C × M × H × I	4,81	1.22	0.89	0.42	0.65	0.48	0.75	1.46	0.48

TABLE IV (Continued)

Source	df	16 September		
		Total	Alfalfa	%Weeds
Cultivar (C)	2, 6	0.43	21.11 *	30.39 *
Harvest mgt. (M)	2, 6	0.88	11.22 *	8.50 *
C × M	4,12	3.25	1.33	0.90
Herbicide (H)	1,81	2.39	88.51 *	154.64 *
Insecticide (I)	1,81	0.54	7.52 *	20.88 *
H × I	1,81	0.19	6.10 *	5.08 *
C × H	2,81	2.59	4.61 *	6.30 *
C × I	2,81	6.93 *	1.66	0.27
C × H × I	2,81	1.28	0.67	0.61
M × H	2,81	0.16	2.15	3.21 *
M × I	2,81	0.93	0.40	0.33
M × H × I	2,81	0.29	2.12	1.41
C × M × H	4,81	0.26	3.54 *	3.44 *
C × M × I	4,81	1.46	0.34	1.01
C × M × H × I	4,81	0.52	0.50	1.32

* significant at $P < 0.05$.

TABLE V

ANALYSIS OF VARIANCE FOR HARVEST YIELD
OF ALFALFA, CHICKASHA, OKLAHOMA,
1987

Source	df	12 May			17 June		
		Total	Alfalfa	%Weeds	Total	Alfalfa	%Weeds
Cultivar (C)	2, 6	5.18 *	4.80	7.50 *	6.67 *	8.86 *	9.65 *
Harvest mgt. (M)	2, 6	12.52 *	1.71	0.54	1.90	0.89	0.67
C × M	4,12	0.31	0.51	1.16	0.70	1.20	1.83
Herbicide (H)	1,81	3.13	73.66 *	144.31 *	153.70 *	91.00 *	3.33
Insecticide (I)	1,81	57.59 *	49.97 *	19.21 *	83.28 *	89.63 *	24.49 *
H × I	1,81	0.07	0.33	2.24	1.79	0.10	0.00
C × H	2,81	4.43 *	0.11	0.70	1.36	0.61	0.03
C × I	2,81	0.47	0.47	0.61	1.06	0.81	0.45
C × H × I	2,81	3.76 *	1.85	0.12	0.62	1.47	0.68
M × H	2,81	1.18	0.45	0.28	0.43	0.50	0.49
M × I	2,81	2.02	0.99	0.61	1.65	2.13	1.97
M × H × I	2,81	0.07	0.74	0.57	0.90	0.64	0.99
C × M × H	4,81	0.06	0.24	0.16	1.33	1.02	0.91
C × M × I	4,81	0.10	0.61	1.09	1.47	1.71	1.55
C × M × H × I	4,81	0.99	1.29	0.86	0.61	1.54	2.22

TABLE V (Continued)

Source	df	21 July Total	21 July Alfalfa	21 July %Weeds	26 August Total	26 August Alfalfa	26 August %Weeds
Cultivar (C)	2, 6	11.72 *	12.04 *	12.32 *	5.08	11.19 *	10.73 *
Harvest mgt. (M)	2, 6	0.28	1.10	2.58	2.33	0.23	0.41
C × M	4,12	1.10	0.20	0.90	0.86	0.82	0.81
Herbicide (H)	1,81	26.95 *	66.60 *	69.57 *	39.28 *	152.24 *	186.37 *
Insecticide (I)	1,81	15.56 *	41.74 *	36.96 *	4.02 *	31.58 *	45.39 *
H × I	1,81	0.51	0.33	1.28	3.63	0.05	0.02
C × H	2,81	3.17 *	0.50	0.04	3.29 *	13.67 *	14.62 *
C × I	2,81	0.49	0.49	1.25	1.19	4.51 *	3.45 *
C × H × I	2,81	0.64	4.31 *	2.71	2.53	1.70	2.00
M × H	2,81	0.44	0.20	0.31	0.07	2.07	1.13
M × I	2,81	0.37	1.38	4.01 *	0.05	1.44	2.16
M × H × I	2,81	3.35 *	1.97	0.26	0.51	0.91	1.22
C × M × H	4,81	0.87	1.00	0.86	0.32	0.37	0.78
C × M × I	4,81	0.86	0.92	1.19	0.90	1.54	1.52
C × M × H × I	4,81	1.96	2.04	1.69	1.30	1.69	2.53 *

* significant at $P < 0.05$.

TABLE VI

ANALYSIS OF VARIANCE FOR SEASONAL HARVEST YIELD OF ALFALFA, CHICKASHA, OKLAHOMA

Source	df	1983 Total	1983 Alfalfa	1983 % weeds	1984 Total	1984 Alfalfa	1984 % weeds
Cultivar (C)	2, 6	0.30	0.38	0.99	2.14	2.72	1.81
Harvest mgt. (M)	2, 6	44.08 *	45.64 *	0.51	0.92	0.80	3.92
C × M	4,12	0.62	0.68	1.20	0.01	0.01	0.52
Herbicide (H)	1,81	0.22	0.33	70.99 *	0.01	0.26	17.62 *
Insecticide (I)	1,81	8.76 *	10.06 *	6.40 *	0.18	0.40	4.68 *
H × I	1,81	0.11	0.24	2.44	0.93	0.56	4.59 *
C × H	2,81	0.86	0.79	1.26	0.04	0.15	4.26 *
C × I	2,81	0.04	0.14	2.58	1.51	1.45	1.25
C × H × I	2,81	0.40	0.38	0.43	0.10	0.09	1.29
M × H	2,81	2.43	2.21	1.60	1.10	0.69	3.43 *
M × I	2,81	3.84 *	3.39 *	0.22	1.77	1.87	0.80
M × H × I	2,81	0.74	0.84	0.57	0.27	0.34	0.74
C × M × H	4,81	0.52	0.34	1.15	1.69	1.68	0.80
C × M × I	4,81	0.99	0.91	0.25	0.03	0.03	0.46
C × M × H × I	4,81	1.61	1.71	1.02	0.68	0.69	0.48

TABLE VI (Continued)

Source	df	1985 Total	1985 Alfalfa	1985 % weeds	1986 Total	1986 Alfalfa	1986 % weeds
Cultivar (C)	2, 6	1.80	3.28	6.54 *	12.73 *	18.20 *	18.02 *
Harvest mgt. (M)	2, 6	3.16	3.46	4.00	3.52	14.87 *	5.70 *
C × M	4,12	0.27	1.27	1.31	1.07	1.27	0.38
Herbicide (H)	1,81	0.02	3.64	10.52 *	1.29	128.21 *	320.89 *
Insecticide (I)	1,81	6.10 *	9.86 *	6.89 *	64.00 *	154.72 *	115.29 *
H × I	1,81	0.39	0.17	1.94	0.04	10.26 *	33.64 *
C × H	2,81	0.78	1.83	2.44	1.83	6.45 *	17.19 *
C × I	2,81	0.97	0.18	0.94	3.52 *	1.48	3.91 *
C × H × I	2,81	1.43	0.17	0.35	0.31	0.43	0.10
M × H	2,81	1.42	2.95	8.77 *	0.08	0.09	0.95
M × I	2,81	2.11	0.91	0.74	2.42	1.66	0.91
M × H × I	2,81	0.59	0.60	1.36	0.20	0.35	0.57
C × M × H	4,81	0.37	1.55	3.34	0.79	1.13	2.18
C × M × I	4,81	0.51	0.98	1.61	0.67	0.38	1.03
C × M × H × I	4,81	1.94	1.59	0.85	1.07	0.83	1.31

TABLE VI (Continued)

Source	df	1987 Total	1987 Alfalfa	1987 % weeds	Study total 1983-1987 Total	Study total 1983-1987 Alfalfa	Study total 1983-1987 % weeds
Cultivar (C)	2, 6	8.74 *	8.87 *	11.33 *	9.29 *	13.46 *	16.28 *
Harvest mgt. (M)	2, 6	13.79 *	1.74	1.02	2.78	4.29	2.68
C × M	4,12	0.30	0.17	0.28	0.30	0.52	0.37
Herbicide (H)	1,81	57.59 *	174.12 *	179.00 *	4.92 *	105.12 *	275.74 *
Insecticide (I)	1,81	86.40 *	98.45 *	60.13 *	61.23 *	109.55 *	76.74 *
H × I	1,81	1.86	0.39	1.41	0.02	1.76	10.40 *
C × H	2,81	7.20 *	1.34	0.92	1.91	0.98	0.49
C × I	2,81	0.73	1.56	0.07	2.28	0.60	0.35
C × H × I	2,81	4.55 *	3.80 *	1.16	0.91	0.71	0.24
M × H	2,81	0.95	0.86	0.08	0.85	0.07	1.26
M × I	2,81	1.06	1.90	1.58	3.11 *	2.40	0.23
M × H × I	2,81	0.39	0.31	1.20	0.30	0.56	1.00
C × M × H	4,81	0.70	0.48	0.42	0.49	0.43	0.66
C × M × I	4,81	1.04	1.61	1.53	0.66	0.86	2.41
C × M × H × I	4,81	0.37	2.25	2.39	1.14	2.24	2.91 *

* significant at $P < 0.05$

TABLE VII

ANALYSIS OF VARIANCE FOR STEM DENSITY OF ALFALFA, CHICKASHA, OKLAHOMA, 1983-1985

Source	df	1983	1984		1985		
		9 May	8 May	18 June	4 Apr.	14 June	5 Nov.
Cultivar (C)	2, 6	2.73	3.52	4.23	14.44 *	7.30 *	4.44 *
Harvest mgt. (M)	2, 6	1.69	0.86	0.02	1.79	0.40	1.28
C × M	4,12	0.73	1.94	0.80	0.64	1.96	0.13
Herbicide (H)	1,81	1.04	1.64	0.55	2.44	2.55	0.08
Insecticide (I)	1,81	5.47 *	0.30	0.69	0.30	1.19	0.29
H × I	1,81	0.03	0.15	2.08	0.37	0.05	0.00
C × H	2,81	0.82	0.07	0.21	2.52	0.86	5.85 *
C × I	2,81	0.58	0.11	0.08	0.82	1.06	1.90
C × H × I	2,81	0.82	2.79	0.06	0.59	0.30	0.74
M × H	2,81	0.70	1.17	0.10	0.51	0.88	1.91
M × I	2,81	6.32 *	2.31	1.20	2.21	1.37	0.04
M × H × I	2,81	6.29 *	0.13	0.35	1.09	0.35	0.06
C × M × H	4,81	3.40 *	0.67	0.91	1.40	1.53	2.64 *
C × M × I	4,81	0.60	0.51	0.53	0.80	1.06	1.42
C × M × H × I	4,81	1.89	2.91 *	1.28	0.80	0.98	0.66

* significant at P < 0.05

TABLE VIII

ANALYSIS OF VARIANCE FOR STEM DENSITY OF ALFALFA,
CHICKASHA, OKLAHOMA, 1986-1987

Source	df	1986				1987				
		15 Apr.	16 May	2 July	28 Oct.	28 Apr.	10 June	14 July	18 Aug.	Sept. 22
Cultivar (C)	2, 6	18.10 *	17.44 *	12.13 *	6.19	0.37	9.24 *	14.21 *	9.68 *	8.27 *
Harvest mgt. (M)	2, 6	4.81	1.87	0.27	4.88	4.23	0.86	1.11	0.14	0.80
C × M	4,12	0.45	1.27	1.45	1.59	0.64	1.65	1.86	2.00	0.98
Herbicide (H)	1,81	47.75 *	19.22 *	1.40	51.50 *	29.13 *	57.98 *	52.67 *	93.62 *	46.50 *
Insecticide (I)	1,81	63.90 *	42.11 *	22.56 *	21.28 *	39.43 *	45.60 *	36.05 *	34.15 *	19.73 *
H × I	1,81	5.11 *	0.36	0.22	0.71	0.32	0.43	0.03	0.40	0.09
C × H	2,81	3.32 *	2.17	1.77	3.12	0.23	0.90	1.29	4.49 *	0.48
C × I	2,81	4.41 *	3.16 *	1.85	0.00	0.14	2.11	1.98	5.34 *	0.41
C × H × I	2,81	0.32	0.12	1.56	3.58 *	0.94	2.06	2.24	0.13	0.70
M × H	2,81	0.92	0.57	0.98	0.75	0.03	0.93	2.10	2.66	0.09
M × I	2,81	0.32	0.56	1.38	0.00	1.04	1.53	0.47	0.24	0.43
M × H × I	2,81	0.62	2.00	0.11	0.77	1.11	0.52	0.79	1.65	0.56
C × M × H	4,81	0.57	2.01	1.70	1.34	0.56	1.27	0.74	2.40	0.35
C × M × I	4,81	1.19	0.41	0.86	1.34	0.41	1.45	0.74	0.78	0.75
C × M × H × I	4,81	0.79	1.11	1.58	1.53	1.10	2.17	3.13	3.96 *	4.41 *

* significant at $P < 0.05$

TABLE IX

ANALYSIS OF VARIANCE FOR HYPERA POSTICA EGG POPULATIONS, CHICKASHA, OKLAHOMA, 1983-1986

Source	df	1982-83			1983-84		
		14 Dec.	8 Jan.	25 Feb.	8 Dec.	11 Jan.	9 Mar.
Cultivar (C)	2, 6	1.61	0.43	0.55	5.23 **	0.06	0.06
Harvest mgt. (M)	2, 6	0.98	4.06	19.52 **	21.33 **	27.75 **	8.21 **
C x M	4,12	2.25	0.91	0.40	1.28	0.17	2.07

Source	df	1984-85			1985-86		
		4 Jan.	14 Feb.	8 Mar.	17 Dec.	2 Jan.	25 Feb.
Cultivar (C)	2, 6	0.09	0.54	3.29	0.30	0.72	1.62
Harvest mgt. (M)	2, 6	91.61 **	30.86 **	77.53 **	22.84 **	76.40 **	6.73 **
C x M	4,12	1.15	0.37	0.49	0.36	0.39	0.83

df= degrees of freedom, * significant at $P < 0.05$.

TABLE X

ANALYSIS OF VARIANCE FOR HYPERA POSTICA EGG POPULATIONS, CHICKASHA, OKLAHOMA, 1986-1987

Source	df	1986-87		
		2 Dec.	19 Dec.	19 Feb.
Cultivar (C)	2, 6	68.43 **	36.30 **	7.90 **
Harvest mgt. (M)	2, 6	5.27 **	43.67 **	11.42 **
C x M	4, 12	1.44	5.09 **	3.19 **
Herbicide (H)	1,211	11.61 **	4.14 **	6.83 **
C x H	2,211	0.70	0.10	0.05
M x H	2,211	0.07	2.43	3.68 **
C x M x H	4,211	0.19	0.30	1.32

TABLE XI

ANALYSIS OF VARIANCE FOR HYPERA POSTICA PEAK LARVAL POPULATIONS, CHICKASHA, OKLAHOMA, 1983-1987

Source	df	1983		1984		1986		1987	
		#/stem	#/0.1 m^2	#/stem	#/0.1 m^2	#/stem	#/0.1 m^2	#/stem	#/0.1 m^2
Cultivar (C)	2, 6	4.51	4.39	2.11	1.75	1.14	13.32 **	15.09 **	1.30
Harvest mgt.	2, 6	0.40	0.73	13.87 **	11.09 **	14.81 **	2.42	16.87 **	1.42
C x M	4,12	0.45	0.69	0.21	0.66	6.63 **	8.13 **	1.07	0.33
Herbicide (H)	1,81	0.72	1.18	0.14	0.26	20.51 **	3.41	1.36	14.94 **
Insecticide (I)	1,81	658.18 **	701.33 **	242.63 **	220.55 **	1390.39 **	788.35 **	452.33 **	36.26 **
H x I	1,81	0.36	0.66	0.27	0.30	9.08 **	5.31 **	3.23	10.58 **
C x H	2,81	0.26	0.36	0.03	0.10	4.86 **	6.99 **	1.23	0.41
C x I	2,81	4.60 **	3.80 **	2.83	1.93	1.97	32.45 **	13.39 **	4.67 **
C x H x I	2,81	0.50	0.61	0.19	0.03	3.67 **	5.67 **	0.90	1.04
M x H	2,81	0.19	0.23	1.04	1.07	3.61 **	5.78 **	1.56	0.99
M x I	2,81	0.29	0.90	11.42 **	10.84 **	19.44 **	5.19 **	11.13 **	0.25
M x H x I	2,81	0.10	0.17	0.87	0.83	3.52 **	6.78 **	2.01	1.54
C x M x H	4,81	1.51	0.90	0.09	0.17	2.90 **	3.42 **	2.00	0.59
C x M x I	4,81	0.48	1.02	0.62	1.21	2.72 **	1.94	0.99	0.61
C x M x H x I	4,81	1.95	1.21	0.04	0.16	4.93 **	5.37 **	0.40	0.27

TABLE XII

ANALYSIS OF VARIANCE FOR ROOT TOTAL NONSTRUCTURAL CARBOHYDRATES (TNC) AND PERCENT DRY MATTER (%DM), CHICKASHA, OKLAHOMA, 1985-1986

Source	df	8 Nov.		14 Jan.		20 Feb.		8 Apr.	
		TNC	%DM	TNC	%DM	TNC	%DM	TNC	%DM
Cultivar (C)	2, 6	3.60	3.35	6.76 *	14.38 *	19.92 *	37.42 *	16.39 *	12.87 *
Harvest mgt. (M)	2, 6	0.51	2.18	7.83 *	14.34 *	23.08 *	539.42 *	2.70	18.23 *
C x M	4,12	1.78	0.63	1.51	1.05	1.38	1.45	1.04	1.40
Insecticide (I)	1,27	.	.	.	.	.	.	59.79 *	0.14
C x I	2,27	.	.	.	.	.	.	1.12	4.89 *
M x I	2,27	.	.	.	.	.	.	1.92	2.49
C x M x I	4,27	.	.	.	.	.	.	1.36	0.88

TABLE XIII

ANALYSIS OF VARIANCE FOR ROOT TOTAL NONSTRUCTURAL CARBOHYDRATES (TNC) AND PERCENT DRY MATTER (%DM), CHICKASHA, OKLAHOMA, 1986-1987

Source	df	19 Nov.		19 Dec.		19 Feb.		23 Apr.	
		TNC	%DM	TNC	%DM	TNC	%DM	TNC	%DM
Cultivar (C)	2, 6	2.17	2.17	12.74 *	12.74 *	6.74 *	6.74 *	1.61	1.61
Harvest mgt. (M)	2, 6	0.21	0.21	1.19	1.19	3.07	3.07	3.00	3.00
C x M	4,12	1.28	1.28	2.34	2.34	0.82	0.82	1.46	1.46
Insecticide (I)	1,27	.	.	.	.	2.21	2.21	0.19	0.19
C x I	2,27	.	.	.	.	1.09	1.09	0.37	0.37
M x I	2,27	.	.	.	.	0.15	0.15	0.36	0.36
C x M x I	4,27	.	.	.	.	0.69	0.69	1.48	1.48

TABLE XIV

ANALYSIS OF VARIANCE FOR ALFALFA PLANT HEIGHTS, CHICKASHA, OKLAHOMA, 1986-1987

Source	df	1986		1987	
		25 Feb.	28 Apr.	22 Apr.	5 May
Cultivar (C)	2, 6	3.03	14.07 *	9.44 *	9.43 *
Harvest mgt. (M)	2, 6	3.00	2.80	19.75 *	14.85 *
C × M	4,12	1.12	1.83	0.92	0.49
Herbicide (H)	1,81	.	4.88 *	0.61	9.45 *
Insecticide (I)	1,81	.	1222.03 *	235.73 *	252.36 *
H × I	1,81	.	1.54	0.95	3.28
C × H	2,81	.	0.50	0.07	0.01
C × I	2,81	.	0.02	7.25 *	3.32 *
C × H × I	2,81	.	0.42	4.09 *	3.67 *
M × H	2,81	.	0.08	0.92	0.31
M × I	2,81	.	2.88	5.80 *	0.48
M × H × I	2,81	.	0.46	1.07	0.47
C × M × H	4,81	.	1.74	0.48	1.25
C × M × I	4,81	.	1.12	0.78	1.03
C × M × H × I	4,81	.	0.85	0.16	0.13

TABLE XV

ANALYSIS OF VARIANCE FOR SEASONAL DOLLAR VALUE
OF ALFALFA, CHICKASHA, OKLAHOMA, 1983

Source	df	Gross $/ha	Adj. $/ha	Gross $/Mg	Adj. $/Mg	Cost $/Mg
Cultivar (C)	2, 6	0.56	0.60	1.65	2.08	1.03
Harvest mgt. (M)	2, 6	37.75 *	17.81 *	194.24 *	111.52 *	194.26 *
C × M	4,12	0.60	0.62	1.09	0.70	0.65
Herbicide (H)	1,81	16.17 *	0.61	239.68 *	1.76	3105.22 *
Insecticide (I)	1,81	13.88 *	0.92	17.38 *	22.23 *	931.84 *
H × I	1,81	0.96	0.96	7.00 *	5.06 *	0.49
C × H	2,81	0.72	0.72	0.38	0.31	0.35
C × I	2,81	0.35	0.35	2.51	1.89	0.10
C × H × I	2,81	0.36	0.36	0.13	0.14	0.29
M × H	2,81	1.65	1.65	0.23	0.16	0.21
M × I	2,81	2.60	2.60	1.07	0.68	0.74
M × H × I	2,81	0.89	0.89	0.51	0.38	0.21
C × M × H	4,81	0.45	0.45	0.73	0.64	0.30
C × M × I	4,81	0.84	0.84	2.35	2.02	0.50
C × M × H × I	4,81	1.78	1.78	0.89	1.05	0.34

TABLE XVI

ANALYSIS OF VARIANCE FOR SEASONAL DOLLAR VALUE OF ALFALFA, CHICKASHA, OKLAHOMA, 1984

Source	df	Gross $/ha	Adj. $/ha	Gross $/Mg	Adj. $/Mg	Cost $/Mg
Cultivar (C)	2, 6	3.53	3.46	0.69	0.97	1.90
Harvest mgt. (M)	2, 6	0.74	0.54	42.29 *	53.37 *	184.22 *
C × M	4,12	0.03	0.03	0.82	0.87	0.31
Herbicide (H)	1,81	2.59	1.33	41.22 *	24.12 *	3257.06 *
Insecticide (I)	1,81	0.99	0.36	6.71 *	14.13 *	1022.68 *
H × I	1,81	0.14	0.14	6.40 *	5.24 *	1.45
C × H	2,81	0.42	0.42	5.06 *	4.44 *	0.68
C × I	2,81	1.34	1.34	1.74	1.59	0.45
C × H × I	2,81	0.17	0.17	1.70	1.61	0.99
M × H	2,81	0.22	0.22	4.93 *	4.28 *	0.58
M × I	2,81	1.84	1.84	0.71	0.89	0.61
M × H × I	2,81	0.41	0.41	0.47	0.49	0.07
C × M × H	4,81	1.86	1.86	0.49	0.70	1.02
C × M × I	4,81	0.03	0.03	0.66	0.51	0.30
C × M × H × I	4,81	0.82	0.82	0.60	0.71	0.82

TABLE XVII

ANALYSIS OF VARIANCE FOR SEASONAL DOLLAR VALUE
OF ALFALFA, CHICKASHA, OKLAHOMA, 1985

Source	df	Gross $/ha	Adj. $/ha	Gross $/Mg	Adj. $/Mg	Cost $/Mg
Cultivar (C)	2, 6	3.20	3.13	4.72	4.54	2.18
Harvest mgt. (M)	2, 6	4.81	7.42 *	9.04 *	13.69 *	854.37 *
C × M	4,12	0.57	0.55	0.69	0.72	0.59
Herbicide (H)	1,81	1.22	3.53	3.42	10.09 *	5210.88 *
Insecticide (I)	1,81	14.93 *	4.60 *	15.74 *	1.27	1601.51 *
H × I	1,81	0.27	0.27	2.50	2.09	2.34
C × H	2,81	0.40	0.40	0.32	0.23	1.40
C × I	2,81	0.15	0.15	1.29	1.15	0.38
C × H × I	2,81	0.34	0.34	0.14	0.09	0.90
M × H	2,81	1.94	1.94	5.82 *	5.53 *	0.32
M × I	2,81	0.64	0.64	1.20	1.12	1.12
M × H × I	2,81	0.57	0.57	1.50	1.48	0.06
C × M × H	4,81	0.81	0.81	1.79	1.78	0.16
C × M × I	4,81	1.05	1.05	1.60	1.68	0.76
C × M × H × I	4,81	1.67	1.67	0.97	0.98	0.78

TABLE XVIII

ANALYSIS OF VARIANCE FOR SEASONAL DOLLAR VALUE
OF ALFALFA, CHICKASHA, OKLAHOMA, 1986

Source	df	Gross $/ha	Adj. $/ha	Gross $/Mg	Adj. $/Mg	Cost $/Mg
Cultivar (C)	2, 6	22.32 *	22.39 *	34.63 *	35.44 *	23.98 *
Harvest mgt. (M)	2, 6	13.38 *	24.29 *	16.35 *	22.46 *	332.49 *
C × M	4,12	0.83	0.84	0.87	1.00	2.76
Herbicide (H)	1,81	70.57 *	15.20 *	285.33 *	69.98 *	2265.40 *
Insecticide (I)	1,81	156.67 *	99.19 *	111.91 *	46.85 *	426.52 *
H × I	1,81	0.29	0.28	4.83 *	2.68	9.32 *
C × H	2,81	0.05	0.05	0.33	0.78	6.30 *
C × I	2,81	0.00	0.00	1.41	1.32	0.08
C × H × I	2,81	0.32	0.32	1.11	1.45	0.86
M × H	2,81	0.17	0.26	0.05	0.27	6.69 *
M × I	2,81	2.26	2.22	1.20	1.37	1.36
M × H × I	2,81	0.01	0.01	0.40	0.42	0.16
C × M × H	4,81	0.80	0.80	1.01	0.97	0.61
C × M × I	4,81	0.47	0.48	0.57	0.45	1.34
C × M × H × I	4,81	0.80	0.81	0.93	0.83	0.97

TABLE XIX

ANALYSIS OF VARIANCE FOR SEASONAL DOLLAR VALUE OF ALFALFA, CHICKASHA, OKLAHOMA, 1987

Source	df	Gross $/ha	Adj. $/ha	Gross $/Mg	Adj. $/Mg	Cost $/Mg
Cultivar (C)	2, 6	8.39 *	8.22 *	10.69 *	10.06 *	5.27 *
Harvest mgt. (M)	2, 6	4.07	4.07	0.73	0.80	6.20 *
C × M	4,12	0.13	0.13	0.08	0.00	1.90
Herbicide (H)	1,81	133.54 *	53.34 *	130.95 *	11.92 *	1154.96 *
Insecticide (I)	1,81	95.92 *	53.95 *	36.96 *	3.79	306.93 *
H × I	1,81	0.01	0.01	1.32	4.26 *	23.18 *
C × H	2,81	0.36	0.36	9.47 *	10.97 *	5.57 *
C × I	2,81	2.16	2.16	1.39	1.96	2.59
C × H × I	2,81	3.11 *	3.11 *	0.76	1.11	7.43 *
M × H	2,81	1.50	1.50	0.47	0.83	1.98
M × I	2,81	2.12	2.12	1.85	1.53	0.03
M × H × I	2,81	0.38	0.38	2.62	2.57	0.30
C × M × H	4,81	0.46	0.46	0.67	0.57	0.78
C × M × I	4,81	0.98	0.98	1.25	1.17	0.33
C × M × H × I	4,81	1.31	1.31	2.03	1.89	0.48

TABLE XX

ANALYSIS OF VARIANCE FOR TOTAL DOLLAR VALUE OF ALFALFA, CHICKASHA, OKLAHOMA, 1983-1987

Source	df	Gross $/ha	Cost $/ha	Adj. $/ha	Gross $/Mg	Adj. $/Mg
Cultivar (C)	2, 6	12.27 *	69.77 *	11.92 *	14.32 *	14.12 *
Harvest mgt. (M)	2, 6	4.89	2169.72 *	7.00 *	35.00 *	43.37 *
C × M	4,12	0.27	1.13	0.25	0.64	0.67
Herbicide (H)	1,81	65.10 *	99999.99 *	3.06	272.51 *	4.49 *
Insecticide (I)	1,81	90.72 *	99999.99 *	34.79 *	94.22 *	4.85 *
H × I	1,81	0.18	0.05	0.18	3.79	1.11
C × H	2,81	0.12	0.27	0.12	0.76	1.62
C × I	2,81	0.89	0.16	0.89	0.01	0.03
C × H × I	2,81	0.43	0.17	0.44	0.04	0.14
M × H	2,81	0.15	20.94 *	0.16	1.99	1.22
M × I	2,81	1.65	3.62 *	1.65	1.35	1.23
M × H × I	2,81	0.41	0.05	0.41	0.78	0.74
C × M × H	4,81	0.55	0.27	0.55	0.78	0.75
C × M × I	4,81	0.63	0.16	0.63	1.97	1.76
C × M × H × I	4,81	1.46	0.17	1.47	1.41	1.42

VITA

Alan Kirk Dowdy

Candidate for the Degree of

Doctor of Philosophy

Thesis: POPULATION DENSITIES OF THE ALFALFA WEEVIL, HYPERA POSTICA (GYLLENHAL), IN ALFALFA, MEDICAGO SATIVA L., AS INFLUENCED BY FALL HARVEST, WINTER GRAZING, AND WEED CONTROL

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